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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN AND THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION.

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What is Semi-steel?

We make no apology for annexing this caption, though many of our readers will remember it was the title chosen by Mr. H. Field in a paper he presented to the Birmingham Branch of the Institute of British Foundrymen. In that admirable paper much valuable information was given, but no actual definition was offered. The same remark applies to the recent papers by Cameron, McLain and Hogg. These workers, together with every foundryman worthy of the name, know exactly what semi-steel cast iron is, but no one apparently has had the courage to state definitely in a concise form its nature. It is high time that this was done, in order that engineers and buyers may know why the foundryman expects more money for material sold under this heading. He should further be in a position to say that the material supplied does or does not conform with the definition of the material.

In order to form a basis for discussion we submit the following:—*Semi-steel is a cast iron which has had its graphitic structure modified, that is, made finer or nodularised by the incorporation of steel into the charge during its manufacture.*

This definition implies that the high tests associated with semi-steel cast iron are due primarily to steel additions, and that they have not been attained by the use of low-carbon pig-iron (cold-blast) which can produce similar results. Similarly, the results are not due to the simple carburisation of steel scrap by incandescent carbon, the other elements being introduced by ferro-alloys or the like (synthetic cast iron). Again, the definition excludes cast iron which has only had a very small percentage of steel added, as this would not give either a "fine" or a "nodular" graphitic structure, which we have specified. The reason why optional graphitic structures have been included is because semi-steel cast iron shows in large masses thinner plates than ordinary cast iron, whilst in smaller masses a nodular formation is present. A careful examination of the micrographs illustrating Mr. H. J. Young's paper, printed elsewhere in this issue, shows the common variations in graphite structure and distribution.

In the definition submitted no reference has been made to composition, though as a rider it could be stated that:—*In semi-steel cast iron the carbon and silicon contents are usually lower and the manganese content usually higher than is considered normal for cast iron habitually used for similar purposes.*

According to Wüst and Bardenheuer, an all-pearlitic structure is also to be associated with good semi-steel cast iron, but if the engineer or purchaser is fully to realise the exact nature of the material, any definition adopted by foundrymen in general should be of as simple a character as possible. The phases of the subject are:—(i.) a mechanical definition which would merely state that a definite range or percentage of steel has been added during melting; (ii.) a chemical definition specifying low total carbon, low silicon and high manganese, which would still necessitate a reference to the composition of the charge in order to exclude similar products made by other processes; (iii.) a micrographical definition stating the result on the graphitic structure with a reference to mode of manufacture, such as we have outlined.

An excellent opportunity is presented by the International Foundry Congress at Paris for expression of views on this subject, which is of distinct importance, because until semi-steel cast iron has been defined the iron founder is in a position to sell material of a description very far removed from the genuine article.

More American Visitors.

Mr. C. E. Hoyt, the Secretary of the American Foundrymen's Association, has arrived in Europe to participate in the Paris Congress.

Mr. H. M. Lane, who was present at the Manchester Conference of the Institute of British Foundrymen, also hopes to be present in Paris.

Visit of the American Foundrymen's Association.

Welcome at Birmingham.

With the exception of two or three of the American visitors—including Dr. R. Moldenke—the party arrived at Birmingham from Manchester shortly after five o'clock on Tuesday afternoon. They were given a very cordial reception, first of all by Professor Thomas Turner, of the Metallurgical Department of Birmingham University, on behalf of the local Branch of the Institute. On the platform to welcome the visitors were Mr. J. B. Johnson, President of the Birmingham Branch of the Institute, and Mrs. Johnson; Mr. H. L. Reason, Past-President of the Institute of British Foundrymen; Mr. D. Dalrymple and Mr. C. Heggie, both Past-Presidents of the Birmingham Branch; Mr. D. Wilkinson, Mr. W. H. Moore, Mr. H. J. Roe, Secretary, Birmingham Branch; and Mr. W. Deakin, representing Birmingham Chamber of Commerce. After formal introductions, the party adjourned to the Queen's Hotel. Here, in the vesitibule, a few more minutes were spent together, and an intimation was made of the programme for the following day. This included an early departure by motor bus for Soho Foundry, the works of Messrs. W. & T. Avery, Limited, where the visitors were received by Mr. Gilbert C. Vyle, who is this year to be President of the Birmingham Chamber of Commerce. After lunch at the Queen's Hotel, a visit was paid to the Birmingham Aluminium Casting Company, and also the Midland Motor Cylinder Company, Limited, at Smethwick. For the ladies a trip to Worcester was arranged, the journey being made in private cars. *En route* Messrs. Cadbury's model village of Bournville, and the famous brine baths at Droitwich were pointed out. The Cathedral and the porcelain works were, of course, among the principal features of interest at Worcester, not to mention its old half-timbered overhanging houses.

The Birmingham Banquet.

On Wednesday evening the members of the delegation were entertained at dinner at the Queen's Hotel, Birmingham, by the President and members of the Birmingham Branch of the Institute of British Foundrymen. Professor Thomas Turner presided.

Mr. G. C. Vyle on American Foundry Equipment.

After the toast of "The King," submitted by Mr. G. H. Clamer, President of the American Foundrymen's Association, and that of "The President of the U.S.A., given by the Chairman, had been honoured, the toast of "Our Guests" was proposed by Mr. Gilbert C. Vyle, managing director of Messrs. W. & T. Avery, Limited, and President of the Birmingham Chamber of Commerce. He said that when English people visited the United States they came back full of enthusiasm over what they had seen, especially with regard to foundry equipment. Their enthusiasm went so far as to induce them to part with good English money to obtain some of that equipment. It was a curious thing, however, that when it was set to work it did not function on this side of the water in the same way as it did in the U.S.A. He was rapidly coming to the conclusion that what we had neglected to do was to arrange for the shipment of two essentials necessary to the successful working of that equipment—trained American workmen and the American atmosphere, which inspired men to get the maximum production in the minimum time from their equipment.

Mr. J. L. Jones (Past-President of the American Institute of Metals) responded, and gave expression to the appreciation of the visitors of the reception which had everywhere been accorded to them.

Mr. V. E. Minich on British Engineering Practice.

"The City of Birmingham and the Foundry Industry" was proposed by Mr. V. E. Minich (Director of the American Foundrymen's Association). Iron and steel, he said, was the foundation upon which modern civilisation was based. Birmingham was fittingly regarded as the cradle of engineering. In Birmingham many of the early developments took place, and our civilisation owed a debt that could not be estimated and that could never be repaid to the city and to the great engineers and inventors and business men in all departments. Birmingham combined in a unique manner old and new practice. Through the courtesy of Mr. Vyle and the staff of Messrs. Avery's the delegation had been permitted to see the firm's works, which had so much history and tradition within their confines, and it was almost unbelievable that they should have seen there machine tools which were designed and built as long as 125 years ago and which were to-day in successful and profitable operation. They were shown a radial drill in operation which was certainly over 100 years old, while the operator had been in the employ of the firm over 57 years and had been operating the machine longer perhaps than the age of many of the members of the delegation. They were shown the home of Murdoch, whose house was the first in the world to be illuminated by gas. The sight of these things, which in a sense were relics but which also were modern, filled him with awe. Side by side with these memorials of the past they saw plant and methods which compared favourably with the most modern manufacturing plants and methods in the U.S.A. He also mentioned the first steam engine built by Boulton & Watt in 1776, operated successfully until 1898, and then removed to Ocker Hill, Tipton, where it was exhibited as one of England's and civilisation's priceless relics. The delegation had also been privileged to visit a couple of the large number of new and modern plants in Birmingham, namely, those of the Birmingham Aluminium Casting Company and the Midland Motor Cylinder Company—plants which would do credit to the greatest and most modern manufacturing plants in America. In the immediate vicinity of Birmingham the first pig-iron made from coal, as distinguished from charcoal iron, was made by Dud Dudley, and that, he assumed, was the forerunner of the great modern development in making pig-iron and producing it in quantity. Birmingham was also the home of a number of men who had done much to advance the science of cast-iron making. The effect of silicon on pig-iron was discovered by their Chairman for that evening, Professor Turner. There were four men who were the leaders in the application of science to the art of ironfounding, and by a happy coincidence two of them were present that evening in person, while a third was represented by his wife and son (Mrs. Thos. D. West). The work so ably started by these men was being developed by the younger generation, among whom was Mr. F. J. Cook. In Birmingham and the Birmingham district was made a range of castings that covered, perhaps, almost every known field of activity, and he was told that there were about 350 foundries in the neighbourhood, including the non-ferrous foundries. He recalled that it was in the city in 1904 that the Institute of British Foundrymen was organised, adding that it had conferred benefits upon everyone interested in the founding of castings. The exchange of papers between Great Britain and America had also been productive of much benefits to the industry, and of perhaps still greater benefit to the Anglo-Saxon race, in bringing together responsible men on both sides of the Atlantic.

Acknowledging the toast, the Lord Mayor (Sir David Davis) said that in Birmingham were manufactured articles of every description. The success and prosperity of the city depended upon its having trade in metal work, at the basis of which was the melting of metals and the foundryman's trade. It was because he was anxious for the progress of Birmingham trade, and that by their visit there will be an exchange of information as to the best methods which might be valuable both to the visitors and to Birmingham, that he had particular pleasure in welcoming the delegation.

On the proposition of Sir Herbert Austin, M.P., the toast of "The Ladies" was honoured, and Mrs. G. H. Clamer replied.

A Note upon Cast Iron for Marine Engine Castings.*

By H. J. Young, F.I.C., and E. Wood, B.Sc.

(*Continued from page* 197.)

Machining Allowances.

Another fault, by no means uncommon, arises through the designer giving little consideration to the proper machining allowance for castings of various types and weights. When a large mould is filled with metal the gases, slag, flotsam, scum, etc., rise to the upper parts; indeed, the more completely this happens the better is the casting. The quantity of débris arising from any particular job depends not only upon the condition and nature of the metal and mould, but upon the amount of metal and the surface area of the mould.

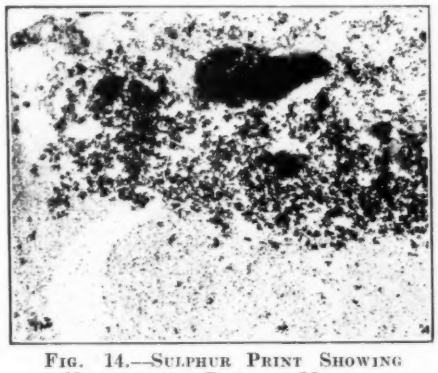
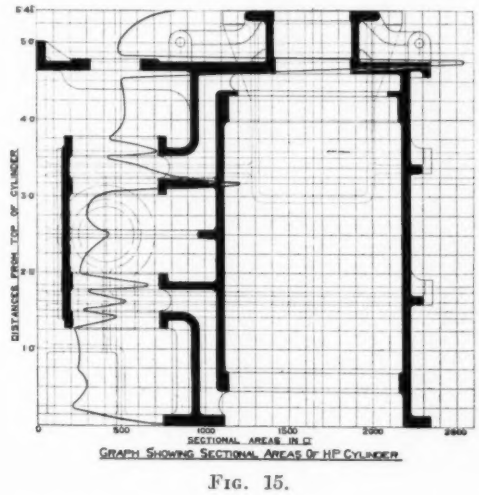


FIG. 14.—SULPHUR PRINT SHOWING NEED FOR PROPER MACHINING ALLOWANCE; 2-3 ACTUAL SIZE.

This type of trouble is shown in Fig. 14, where only $\frac{3}{4}$ in. was allowed for machining, and it is obvious that an additional machining allowance would have produced a clean surface. Some engineers think that the moulders themselves should increase the machining allowance when they consider it is insufficient, but the question arises as to who shall pay for the extra weight and the increased cost of machining. It is unreasonable to expect the moulder to risk doing anything which may cause him to be held responsible for the slightly augmented cost of the job.

Pouring and Gating.

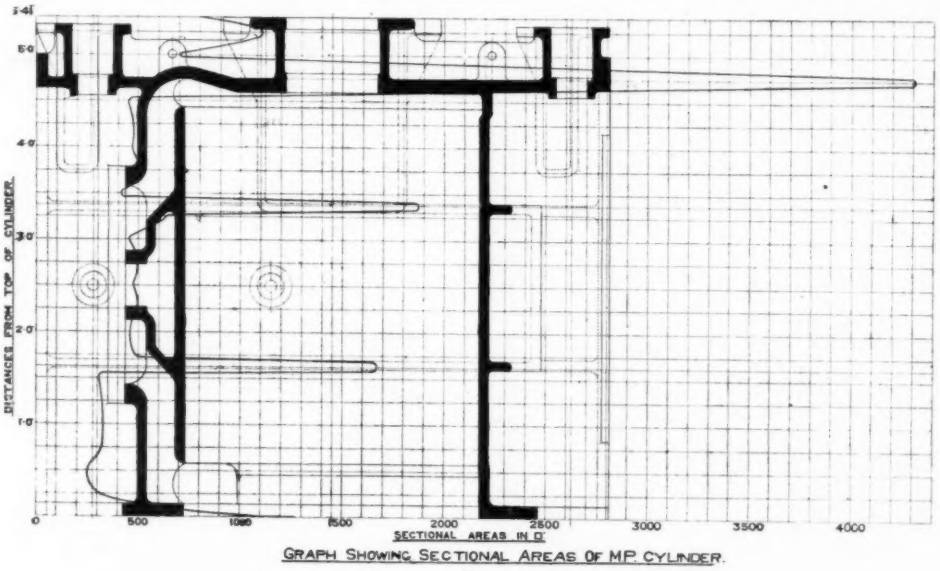
Those interested in foundry matters will be aware of the recent valuable papers and discussions regarding the rate and manner in which castings are poured. The discussion has been limited mainly to small castings, and, while working on some of the points raised, the authors have obtained many interesting results by variation of the rate and the manner of pouring of small jobs; the knowledge thus acquired is being applied gradually to large and heavy castings.



GRAPH SHOWING SECTIONAL AREAS OF HP CYLINDER

FIG. 15.

When investigating the speed of pouring ordinary marine engine cylinders, diagrams were made showing the sectional area of a cylinder in square inches at various distances from the bottom of the mould. In the examples, Figs. 15, 16 and 17, the cylinders are presumed to be cast with stuffing-boxes upwards. It will be noticed that an enormous variation of volume takes place at the crown, particularly in the case of the low-pressure cylinder. For cast-iron propellers a similar curve, Fig. 18, was made.



GRAPH SHOWING SECTIONAL AREAS OF MP CYLINDER.

FIG. 16.

With the introduction of special irons for definite classes of work—such as Diesel cylinders, cylinder liners for use with superheated steam, flywheels, cams, Diesel pistons, piston rings, etc.—each of which is made from a different grade of iron, great

* A Paper presented to the Institute of Marine Engineers at the Olympia Exhibition.

care is necessary to ensure that the correct metal gets into the correct casting and nowhere else. The right type of metal for any particular job can be ascertained only by consultation between the foundryman, the engineer and the chemist.

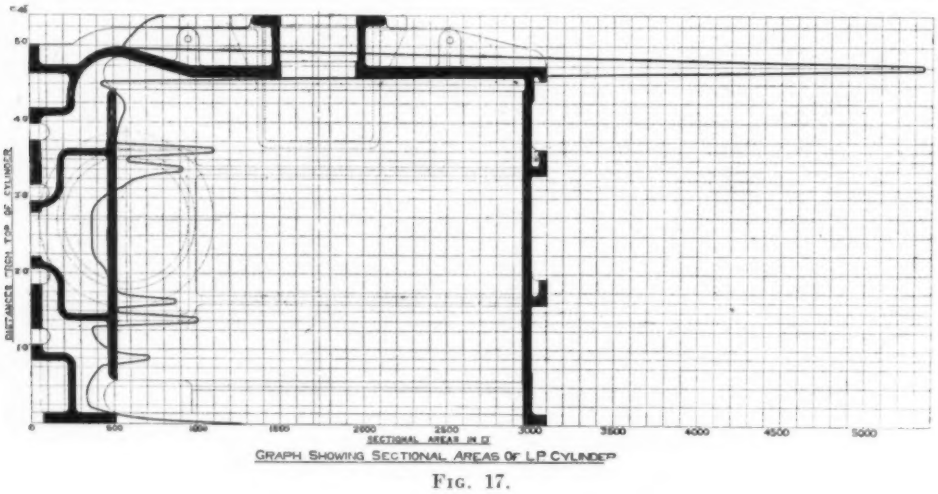


FIG. 17.

Separation of Charges.

It is impracticable, whilst maintaining standard melting conditions, to separate mixtures of widely different properties in the cupola; for instance, if a mixture for hard cylinder liner metal is charged

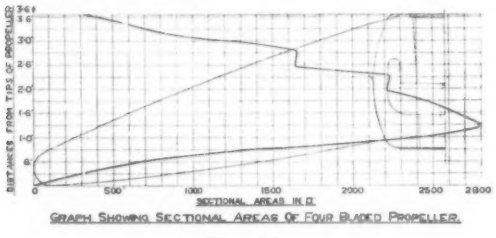


FIG. 18.

into the cupola and followed by one for ordinary bedplate metal, the liner metal will be contaminated by the bedplate mixture and the bedplate metal by the liner mixture.

Very high-class iron of predetermined properties and composition can be produced only under special melting conditions; by complete control of the melting practice it is commercially possible to produce, time after time, cast iron having the same total carbon, silicon, phosphorus, sulphur and manganese contents, and the same physical properties. This cannot be done if more than one mixture is put into the cupola or if the precise rations of air to coke and of coke to metal are not maintained unaltered throughout the melt.

It would appear to be easier to produce standard cast iron from a cupola than from an open-hearth or an electric furnace. Such samples of metal from the latter processes as have been examined by the authors are anything but standard, their composition and properties appearing to vary from melt to melt. It seems therefore that either these latter processes are more difficult to control or those attempting to control them are inexperienced in iron-foundry metallurgical problems.

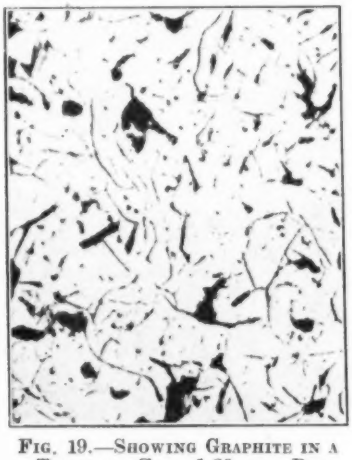


FIG. 19.—SHOWING GRAPHITE IN A TEST-BAR CAST 1.26 IN. DIA., GIVING FAIRLY LOW RESULT. MAGNIFIED 75 DIAS.

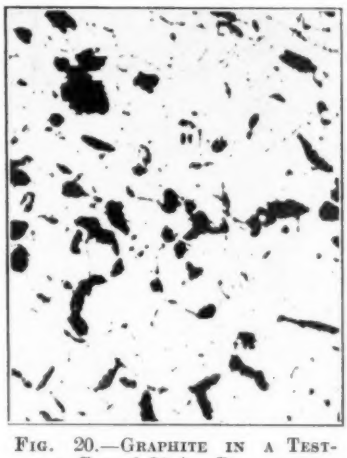


FIG. 20.—GRAPHITE IN A TEST-BAR CAST 1.26 in. DIA., GIVING A FAIRLY HIGH RESULT. MAGNIFIED 75 DIAS.

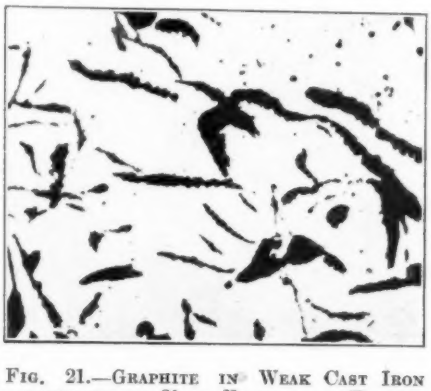


FIG. 21.—GRAPHITE IN WEAK CAST IRON TAKEN FROM A 2½-IN. FLANGE OF A TURBINE CASING. MAGNIFIED 75 DIAS.

Each grade of iron has its own foundry properties, and therefore the moulds, the manner of filling them, and the feeding heads must be suitable. These things are discoverable only by trial and error.

In order to illustrate the appearance of graphite in cast iron, the authors present as typical the two types shown in Figs. 19 and 20. Both are transverse test bars of 1.26 in. diameter, tested rough (as cast) between supports 12 in. apart, the first

FIG. 22.—GRAPHITE IN NORMAL GOOD IRON TAKEN FROM A 2½-IN. FLANGE OF A LARGE CASTING. MAGNIFIED 75 DIAS.

bar being a weak iron breaking under a load of, say, 2,800 lbs., and the second a stronger iron breaking at about 3,700 lbs. These test bars, cast apart from the casting, are useful for laboratory purposes, but, for many reasons, are of small value in practice.

An example of a metal unsuitable for the purpose to which it was applied is that of Fig. 21, which is the graphite in a test bar cut out of an L.P. turbine casting, weighing about 12 tons. The test bars were required to be cut out of an extended flange, 2½ in. thick, and to give tests of 11 tons per sq. in. and 2,500 lbs., transverse. Instead, they gave only 9.08 tons per sq. in. and 2,422 lbs. respectively.

A better metal is shown in Fig. 22, which, at a

FIG. 23.—GRAPHITE IN DIESEL IRON TAKEN FROM THE BOTTOM OF A CASTING 12 FT. LONG, 2½ IN. THICK, WEIGHING 3½ TONS. MAGNIFIED 75 DIAS.

casting thickness of about 2½ in., has a tensile strength of about 13 tons per sq. in. and a transverse strength of about 3,000 lbs.

For Diesel cylinders and liners it has been necessary to develop a special metal which can be reproduced with great accuracy both with respect to composition and physical properties. A casting of this metal, recently rejected on account of an error, became available for test purposes, and a series of test bars, from the extreme top and bottom sections of the casting, were cut. The casting itself was 12 ft. long, about 2½ in. thick, and weighed 3½ tons, representing one of a number made with every success. The tests are given in Table I.

Fig. 23 shows the graphite in the test bars cut out of the bottom part of the casting, and Fig. 24 that of the bars from the top part. Metal of this constant character was attained gradually, with no consideration whatsoever of the brand or the fracture of the pig-irons used, by metallurgical control and understanding of the composition and manufacture of cast iron in a cupola furnace.

The difficulties of making perfect castings from high grade cast iron are very great, particularly when a small pinhole in the bore of a Diesel cylinder or liner is sufficient to condemn it. Much depends upon the personal co-operation of the foundryman, and in having one with that spirit which makes him strive to discover how to make a proper casting of such metal, rather than one who continually deplores the obvious fact that he is not using the mixtures prescribed by his forefathers. It should not be more difficult to make a perfect casting of

TABLE I.—*Showing tests taken from the top and bottom of a Diesel Cylinder.*

Position of test bar in casting.	Casting thickness.	Tensile tons per sq. in.	Transverse.		Hardness.	
			Breaking Load. lbs.	Deflection. ins.	Brinell. Av.	Scleroscope. Av.
Cut from bottom	2½ in.	18.38	3632.5	0.177	204	32
,, ,, ,,	2½ in.	18.24	3692.1	0.177	207	32
,, ,, ,,	2½ in.	18.80	3612.7	0.177	202	31
,, ,, ,,	2½ in.	18.14	3672.2	0.187	199	32
,, ,, ,,	2½ in.	18.32	3731.8	0.172	204	31
,, ,, ,,	2½ in.	18.34	3612.7	0.157	200	32
,, ,, ,,	2½ in.	18.17	3731.8	0.177	207	33
MEAN RESULTS		18.34	3669.4	0.175	203	32
Cut from top	2½ in.	17.48	3731.8	0.197	195	31
,, ,, ,,	2½ in.	17.48	3592.8	0.162	188	32
,, ,, ,,	2½ in.	16.30	3354.6	0.157	198	30
,, ,, ,,	2½ in.	17.72	3414.2	0.162	202	32
,, ,, ,,	2½ in.	16.28	3324.8	0.153	198	31
,, ,, ,,	2½ in.	16.52	3475.7	0.167	199	31
,, ,, ,,	2½ in.	16.24	3453.9	0.162	204	32
MEAN RESULTS		16.69	3479.4	0.166	198	31

Transverse bars are machined to 1 in. sq. and tested between supports 12 in. apart.

high-class cast iron than one of high-class steel, but, considering the large quantity of metallurgical work which has been done on steel and the very small amount on cast iron, it is sufficiently difficult.

FIG. 24.—GRAPHITE IN DIESEL IRON TAKEN FROM THE TOP OF THE SAME CASTING AS FIG. 23. MAGNIFIED 75 DIAS.

The authors desire, in conclusion, to express their thanks to Mr. Summers Hunter, of the North-Eastern Marine Engineering Co., and Past-President of the Institute of Marine Engineers, not only for his permission to read this Paper, but also for the interest he has taken in, and the encouragement he has given to, everything connected with progress in ironfoundry work.

Their thanks are due also to Mr. C. Gresty for his work in producing the photographs and lantern slides.

THE BRADFORD CORPORATION ELECTRICITY COMMITTEE recently had under their consideration the placing of a large electrical contract, the British tenders being higher than several concerns. The necessitous state of British industries has been the chief consideration in determining the Committee to place the contract in this country, and as a result an order will be carried out by the English Electric Company, Limited, and C. A. Parsons & Company, Limited. The contract is for a new turbo-alternator of 20,000-kw. capacity, or 28,000 b.h.p., to be installed at the Valley Road Works.

Testing Cast-Iron.*

By Dr. Richard Moldenke, Watchung, N.J., U.S.A.

The procedure of testing iron castings to determine their ability to fulfil the conditions of service is a difficult matter, because of the nature of the material itself. Instead of dealing with a relatively homogeneous material, as is the case with steel and non-ferrous metals and alloys, we have in cast iron a combination consisting of solutions and suspensions in iron of iron carbides, silicides, sulphides and phosphides, as well as manganese carbide and sulphide. And, in addition to all these, there is more or less graphite in mechanical admixture. Further, the proportions of chemically-combined carbon and mechanically-admixed graphite present vary in every piece of cast iron from surface to centre, the extent of this variation depending upon a number of factors connected with the composition and the rate of change from high to low temperatures. There is little wonder that, with such a material to test for its qualities and adaptabilities, progress has been cautious and very slow.

The Present Position.

None the less, there is a genuine desire on the part of both producers and consumers of the foundry product to know as much as possible of the character and value of the castings before they get into actual service. For many lines of castings the purchaser is content with the reputation of the foundry selected for excellence of product, and were all foundries able and content to turn out only the best of work, there would be little need of specifications. But for the protection of the consumer, as well as the insurance of the foundryman himself, it is highly desirable to have simple, but still reliable, methods of testing which will insure excellence in quality in iron castings where this is of sufficient importance to warrant the additional trouble and expense involved.

A study of the history and development of the subject shows that the testing of the castings themselves is resorted to in but few instances, for it is necessary to subject them to forces which may cause their actual destruction. Where such a test is intended to destroy the piece, a few castings are selected from a given carefully-collected group made under identical conditions, and these castings are destroyed under tension, pressure, shock or thermal treatment, and the results are required to exceed certain minima. The chilled iron car wheel is probably the best example of this method of testing finished work.

For other lines of castings which are to stand given service stresses well within the limits of resistance of the material, the individual finished piece is subjected to such stresses in the test room to the extent of 50 or 100 per cent. above the maximum required in service. Pipe, fittings, parts of mechanisms and structures, separately or in assembled state, are thus tested to give reasonable assurance of their fitness for the work demanded of them. Even the "proof test" required of the old cast-iron cannon would come under this category.

But with every desire to test the actual casting, this is not always practicable, and oftentimes is misleading. Apart from the heterogeneity of the metal in the casting, there are the casting strains, interior shrinkages, surface cracks as starting points of rupture, and other irregularities in the physical structure, which must be cared for by large factors of safety embodied in the design, and which make one almost despair of arriving at any safe conclusions from tests of any kind.

The next development seems to be the cutting out of sections of metal from castings and testing these for their qualities. Usually the sound portions of otherwise defective castings are selected for this purpose, and "test coupons" cut from them. The idea is logical enough, and in the case of homogeneous material that has been left in a natural state by final annealing, gives acceptable results. Steel forgings are tested thus, and in the case of malleable and steel castings, coupons are sometimes cut from unessential parts when regular test-bars are unavailable. However, when this is tried with iron castings, it becomes a different matter.

The Fremont Test.

Perhaps the most interesting development of the method of judging a casting by small test-pieces cut directly from it is that of Fremont. Here a hollow drill removes small cores of metal from selected parts of the casting, and these small rods are subsequently prepared for shearing tests. With all the ingenuity involved in working out this method, and the comparative accuracy obtained in the relation of shearing to tension forces for every individual test, the fatal objection is that these cores of metal represent only themselves and not the other parts of the casting. The cores cannot be taken from portions of the casting directly stressed in service, but usually come from the heavier portions and where no damage is done by the operation. Considering the fact that a test core taken close to the surface of a 6-in. cube may be three times as strong as when taken from the centre, the care and cost of the method would seem expended in vain so far as the desired results are concerned. Were a casting reasonably homogeneous from surface to centre, and were there no strains or shrinks to contend with, the Fremont method would be nearly ideal from the scientific standpoint, though rather expensive from the practical one.

Early Methods.

The crystallisation of ideas in connection with the testing of cast iron finally brought out the preparation of test-bars made with the same iron as the castings, and the subjection of such test-bars to proof loads. Some of the older foundrymen may still remember the casting of bars 1 in. sq. in section and sufficiently long to place upon supports 5 ft. apart. A load of 500 lbs. was then carefully lowered for suspension at the middle. Rupture of this bar, whether at once or overnight, as might be demanded, would condemn the castings.

Crude as this method was, yet it formed the beginning of modern procedure in testing the foundry product. The fundamental idea involved, and which must be carefully kept in mind at all times, is that test-bars do not represent the castings made of the same iron, but only the quality of the iron going into these castings. Hence the supreme importance of giving the iron poured into test-bars every opportunity to solidify in a natural way, with neither artificial strengthening nor hindrance from attaining full normal strength. The requisites for these conditions will be discussed further on. It will be noted that this test-bar procedure still involves a deference to the reputation of foundrymen for the quality of their work, for, with ever so good an iron to pour into the moulds for castings, this can be injuriously affected by poor moulding and injudicious gating practices.

Separately-Cast Test-Bars.

The advent of a separately-cast test-bar soon brought about complications between buyer and seller, for human nature in the foundry is just as prone to take advantage of opportunities for substituting bars of stronger iron in place of bars from the regular output, as it is prone to make the buyer believe that all bars he does not himself see cast are spurious. Hence the desire to attach test-bars to the castings as part of the mould. This meant a much shorter bar, and particularly where Government work is involved and business with foundries is conducted at long range, is this undesirable method of coupon-bars still in use to-day. For cast iron, it will make a difference in the results whether the coupon-bar is placed at the top, middle or bottom of the mould; whether strains are present from this attachment; whether

* A Report presented before the International Foundrymen's Convention at Paris, France.

the annealing action of the usually large and long-continued heat transfers from the attached heavy metal masses will not affect the test results unduly; and what the chances are of retaining the coupon intact on the casting through the various processes of shaking-out, cleaning and transportation. It is to be hoped that foundrymen will eventually be spared the moulding of coupon test-bars, which, in addition to being highly troublesome, are made under technically unreliable conditions.

Advent of Arbitration Bar.

As the separately cast test-bars, representing the quality of the iron poured into the castings of the same cupola or furnace melt, began to come into general use—eventually for the foundryman as much as for his customers—the cumbersome lengths were reduced to test at 3 ft. then 2 ft.—as still used to-day in the standard cast-iron pipe test-bars—and finally down to the present American bar, which is placed upon supports a foot apart and broken transversely. Tensile test-pieces were always made short, and saw an evolution from square, flat or round pieces of about a foot in length and gripped by the flat wedges of the testing machine, to the present-day carefully-turned test-pieces made from the broken halves of the arbitration bar and provided with finely-threaded ends, so that alignment in the testing machine may be as nearly perfect as possible before and during test.

In the early test-bar days, a variety of shapes were used. The square bar predominated, usually 1 in. sq. in section, though for years the ½-in. sq. section held its vogue in the light castings shops. The round bar of to-day, for transverse testing was practically unknown at first, and came into use after many series of tests had been made by early investigators. This change and simplification of the test-bar situation was concomitant with the advance in knowledge of the physical and chemical properties of cast iron, and as this information grew in extent, more or less elaborate investigations into the subject were instituted by foundry and engineering bodies the world over. These led to the publication of the results of many testing programmes. The most complete of these ever made—and the last conducted in the United States (in 1898-1900)—was that of the American Foundrymen's Association, the writer of this report being Chairman of the Committee having the matter in charge. The tests involved the pouring of tons of bars of many kinds of iron under the very best of foundry conditions. The results were studied by Committees of the American Foundrymen's Associations and the American Society for Testing Materials jointly, and formed the basis of the Specifications now in use. The leading foundrymen and metallurgists of the United States were members of these committees, and they disregarded customs where these conflicted, and evolved definite lines of procedure which are still standard to-day, and are used where buyer and seller clash in specification contracts.

Necessity for Universal Bar.

Be it understood that the American Standard Arbitration Test-Bar never has, nor ever will, replace the test-bars used in individual foundries that are loth to change their old ways or individual preferences. But for universal comparison of results, it is essential that a standard be adopted with which all other bars can be co-related by suitable factors. A national standard may even consist of several bars of different cross-sections to care for an extended silicon range, and thus cover a wider field in lines of castings than a single bar; but when it comes to an international standard, it would seem essential that but one bar be selected which would cover the metal going into castings used for machinery and pieces of construction, rather than to include such special work as chilled rolls, crusher parts, or the very lightest and thinnest castings in which strength is not essential.

Ring Test.

Among the separately cast test-bars once much affected was the "ring test," in which an annular casting was made of the same iron that was used for the work under consideration. This ring was practically a piece of heavy pipe of short length. From this ring a test-bar was planed out longitudinally and tested for tensile strength. In effect, this was an almost flat bar with the four hard corners removed. Doubtless, the irregularity of the metal at the fracture through interior shrinkages must have caused the abandonment of the method.

Suitability of Arbitration Bar for International Standard.

The American Arbitration Test-bar, and the method of preparing and tseting it, as first advanced by the two societies above mentioned, in 1905, has proved satisfactory to the present day in every respect but its length. When first advanced, the method was ahead of the times. The foundry industry has, however, slowly worked up to it, and the Arbitration Bar is specified for general as well as specific lines of castings to judge the quality of the metal going into the product.

The American foundrymen and engineers are now ready to consider the lengthening of the bar, and possibly increasing the diameter somewhat at the same time. They will be glad, however, to await international action on this point, so that when an International Arbitration Test-bar is adopted, this may possibly be acceptable as the American National Bar.

Cast-Iron Pipe Testing.

So that the reasoning by which the present American test-bar was worked out may be fully understood, the following summary of the arguments used is given in what follows:—First, the section of the bar. The cast-iron pipe industry announced at the outset that they would retain their standard test-bar. It is the same bar as used in Great Britain, namely, 2 in. × 1 in. in section and 26 in. long. It is tested on supports 24 in. apart. The bar is placed flat in American and on edge in British testing. This bar has the advantage of approaching the general distribution of metal in cast-iron pipe. It is long and exhibits elasticity under test. The disadvantage of the bar is the fact that it has four hard edges, as in square bars, so that, when put under transverse centre-loading with maximum strain on the outer fibre of the metal, this is soft in the middle and hard at the ends. Such a bar sliced longitudinally into three sections of equal width will show widely different metal in middle and end pieces. It is to be hoped that, when an international standard bar is agreed upon, that this will be long and flexible enough to replace the antiquated flat cast-iron pipe bar, which does not effectively register serious differences in chemical composition or different pig-scrap relations for equal compositions.

Flat and Round Test-Bars.

The disadvantages with the flat section are those of the square section. On comparison of test results of square bars with round ones of equal sectional area, the former will always be found stronger. This because of the greater proportion of combined carbon—the four edges cooling more rapidly than the balance of the metal. The metal in a square bar is therefore not under as natural a condition of setting and cooling as in a round one, and consequently the round section was determined upon as a matter of basic principle in the American standard. In fact, it might be stated that about the only advantage a square bar has is that it rests better upon the test supports, and the outer fibre of the metal tears along a line rather than at a point.

The disadvantages of the round bar are the concentration of the maximum fibre stress on the lower point of the fracture circle, and the inconvenience of the test-piece for transverse testing. The decisive advantage of the round section bar, however, is the uniform change in the character of the metal from the centre of the bar to every point on the periphery of the fracture circle.

Criticism of the Arbitration Bar.

On the questions of length and diameter of the American Standard Arbitration Bar, there is this much to say:—At the time of the adoption of the bar, practically everyone in America who made bars at all—outside the cast-iron pipe interests—used a length which allowed a transverse breaking test on supports 12 in. apart. The bars therefore varied from 13 in. to 15 in. in length. The question of studying the deflections had not then

assumed any particular importance, as the stronger irons made with steel additions to the mixtures had only made their appearance sporadically. With the general use of steel scrap in mixtures giving a line of castings going under the misnomer "semi-steel," however, the measure of the resilience of cast iron became of interest, and there is a desire manifest for a longer bar which would exhibit deflections that can be differentiated and would mean something. Incidentally, the incorrectness—scientifically—of the term "semi-steel," and the fact that it is used for commercial advantage covering all kinds of steel scrap mixtures, has become generally recognised in America, and hence, through the agency of the American Society for Testing Materials, there has been advanced the term "high-test" cast iron, for want of a better designation; and there are pending at present tentative specifications for this material which, when adopted finally, will differentiate between ordinary cast iron of good quality and the new varieties of much higher strength obtained by the use of heavy steel scrap percentages in the mixtures.

The length of an international bar will probably be a matter of compromise, as nations using short bars will yield on some increase, just as nations using very long bars will agree to a shortening. The International Association for Testing Materials had proposed an international test-bar with dimensions which would be readily convertible in English and metric measurements. It was to be tested on supports 18 in. or 45 cm. apart. The bar itself was to be at least 20 in. or 50 cm. long, to be safe in case of short-pouring the mould. From the reports of testing bodies of the more interested nations, this bar length seems generally acceptable, and it is suggested as a basis for discussion when this matter of an international test-bar is taken up seriously for settlement.

Diameter of Test-Bars.

The question of the test-bar diameter is a matter that may require some further study on the part of the interested foundrymen and engineers of the world. The bar originally proposed was to be 1.2 in. or 30 mm. in diameter. Many of us have made numerous tests with a bar of this diameter, broken on supports 18 in. apart. The curves obtained from these transverse tests on irons of a variety of compositions are not altogether satisfactory, and indicate that the bar is too flexible for its length. Might it not be well first to agree upon the shape of the cross-section and the length of the bar as broken upon supports for test, and then make a study of the desirable diameter of such a bar, so that a proper degree of sensitiveness may be attained for deflection as well as for load? This thought is advanced for the reason that all the other points involved in the selection of an international bar should lend themselves to a ready adjustment, whereas the most advantageous diameter or section for a bar to be broken on supports 18 in. apart has not yet been evolved by systematic study.

The facts upon which the diameter of 1.25 in. for the American Arbitration Bars were based are the following:—It was recognised that the smaller the section, the more the bar would be influenced by sand and temperature conditions. Hence a bar as large as possible was selected which would still give results well within the scope of the usual commercial testing machines in use. As the load maximum for the common American machines is 5,000 lbs., and the 1.25-in. diameter bar, broken on supports 12 in. apart, would fall between 2,500 and 4,500 lbs. for practically all classes of iron, this diameter was fixed upon. Extending the test supports to 18 in. would allow a considerably thicker bar for the international standard, and still be within the scope of the testing machines generally used.

Machining Test-Bars.

The question of machining the test-bars comes up now and then. For the tensile test this is obligatory, as accuracy in alignment is the *sine qua non*, otherwise the results are worthless. In the case of the bar for transverse test, however, American thought has never favoured machining, even if this does remove fine surface cracks that might become the starting points for premature rupture. There are three reasons why machining is not favoured; because of the considerable expense involved, because a reasonable under- or over-size can be readily corrected to bring the results corresponding to standard, and because machining removes the most sensitive part of the bar, for nowhere is the change from high to low combined carbon more rapid in cast iron than right at the skin. With the considerable machining necessary in an extra-large bar, the character of the iron in the outer fibre receiving maximum stress would be far different from that in the standard-sized bar.

Position of Casting.

Should bars be cast flat or on end? It is a well-known fact that, unless a bar cast flat is tested in the same position—that is, cope-side up—the result will be different from that obtained if the bar had been turned around—that is, cope-side down. This is readily understood when one considers what happens to the bottom mould surface, which is heated more and longer by the stream of molten metal poured upon it than the top. The character of the iron, top and bottom of the bar must necessarily be somewhat different. This is the case even if the mould is inclined. To avoid all chances of error, the American Arbitration Bars are cast in the vertical position, and can consequently be tested without regard to top or bottom. The making of a mould which, when set up vertically and poured off, will give a perfect test-bar is not a simple matter, and the first bars turned out by an inexperienced man will look like iron clubs rather than castings of uniform thickness. However, when one has seen bars made by the thousand in cast-iron pipe shops, where they are 26 in. long, are poured in vertical position and leave the mould perfectly, one finds it simply a question of proper flasks and moulding skill.

Sand for Test-Bar Moulds.

Next would come the sand. The results of all the testing programmes carried out show that green-sand bars are stronger than those made in dry sand. Hence, to avoid any question of artificially strengthening the iron in test-bars by the chilling effect of damp sand, the moulds should be dried and allowed to acquire room temperature before being poured off.

Bottom or Top Pouring.

On the subject of "bottom-pour" or "top-pour" for the test-bars, there is some difference of opinion. Perhaps to understand the situation easily, moulds that are poured in each of these two ways should be observed. With the "top-pour" method, the temperature of the molten iron falling into and filling the mould from the bottom upward, to constitute the test-bar as made in vertical position, will be exactly the same for all parts of the bar, with metal at maximum temperature continuously available for feeding-up just where it is required. Whereas, with the "bottom-pour" method, the metal at highest temperature enters the bottom of the mould by a gate and filling up to form the test-bar, is cooled off considerably, as is easily seen by comparing the colour of the molten metal in the riser with that of the pouring basin. Naturally, this colder metal sets before the hotter iron lower down in the test-bar, and, as the thin gate at the bottom also sets before the molten iron in the bottom portion of the mould, there is every chance of an interior shrinkage, or at least porous metal in the lower portion of the casting. To avoid any chances of variation in the character of the metal through different cooling rates as well as imperfect feeding, the American Arbitration Bars are "top" poured.

Tumbling and Strength Increase.

A final precaution taken with the bars when cast is that, in cleaning them, they are not put into tumbling barrels for this purpose, but are simply brushed off to remove adhering sand. Ever since the famous investigations of Outerbridge, who proved conclusively that "tumbling" test-bars would, by relieving molecular stresses, increase the strength very materially, this point has been watched very carefully in making specifications for testing cast iron.

Magnesium in the Foundry.*

By H. J. Maybrey, B.A., D.I.C. M.I.Br.t.F.

Introduction.

In 1914 magnesium had not long ceased to be practically a chemical curiosity. Outside the laboratory, and certain foundries, it was familiar only to a limited public as ribbon or powder.

This does not mean that the metal had received no attention from the practical metallurgist; on the contrary, magnesium was in small percentages an essential constituent of several alloys. One of these, duralumin, was at that time being produced in very considerable quantities. Moreover, in various parts of the world a great deal of research had been done with a view to the development of those alloys in which magnesium formed the main constituent. Nevertheless, magnesium occupied a very lowly position among those metals which engaged the attention of the majority of foundrymen.

The demands of the war stimulated the world interest in aeronautics. The consequent call for lighter structural materials greatly increased the foundryman's interest in magnesium. This, in spite of the comparatively high cost of the metal. The outcome of this interest has been to bring into operation cheaper and more satisfactory methods of manufacturing the metal. Most of the methods in use to-day are based upon the electrolysis of the fused anhydrous magnesium chloride. Other methods employing distillation are in use and seem to work quite successfully. The requisite ores for these processes exist in enormous quantities, and are widely distributed over the surface of the earth.

A cheap and efficient process operating on raw material which is abundant are the main conditions necessary for the production of an inexpensive metal. As it is of little use to produce a commodity unless there is a demand for it, the price paid for that article will always be a function of the demand. This is the case with magnesium. The increasing demand for the metal is steadily lowering its cost. Even now its price is no longer a bar to its use in a very large number of directions. Moreover, as the price of the metal lowers itself, the field of application for the various magnesium alloys will increase rapidly.

To-day magnesium and its alloys are produced commercially in the following forms, and for the various purposes indicated:—(1) Ribbon and powder in all meshes (for photographic and illuminating purposes); (2) sticks, for use as a deoxidiser in brass and steel foundry practice; (3) chill and sand castings, in various forms as pistons, carburettors, crank cases, connecting rods, pulleys, etc.; (4) sheet metal; (5) extrusions, stampings, drop forgings, etc. (for various uses).

General Characteristics of the Metal.

Magnesium is usually supplied to the foundry in the form of notched bar ingots, similar to the usual aluminium notched bar. It is sometimes supplied as sticks about 1 in. dia., or as flat plates. When it is obtained from manufacturers of repute, the metal is almost chemically pure; only a very poor grade of metal would fall below a 99.4 per cent. purity.

Before buying magnesium metal, the foundryman should make an inspection, and note the following points. He should, in the first place, be satisfied with the analysis given for a fair sample of the metal offered. He should note the appearance of the weathered surface of the ingots. He should cause a slab to be broken freshly, and should examine carefully the rough fracture. It is, of course, pleasant to have a bright clean outside surface to the ingot. Often when the ingot is being cast, a very slight oxidation of the metal will cause a blackening of the skin of the block. This is no serious drawback, provided the rough black surface is not too deep. The presence of grey crumbling spots on the ingot surface should, however, be looked upon with the gravest suspicion. On a freshly-fractured surface these spots appear like small "slag" inclusions. They are due to what the manufacturer calls "flux inclusions."

Effect of Magnesium Chloride.

Now magnesium chloride, from which practically all commercial magnesium is manufactured, is an extremely deliquescent substance. The densities of molten magnesium, and of the molten chloride from which it is produced, are only very slightly different, so that there is a tendency, during the process of casting the metal into ingots, to get a certain small amount of magnesium chloride entangled in the solid metal. Only the exercise of a very great amount of skill and care on the part of the manufacturer can cause the ingot metal to leave the works free from contaminations of magnesium chloride. It is obvious that metal containing flux inclusions is likely to be a source of much trouble to the founder. Such metal, when melted and poured into moulds, is likely to produce a casting whose surface is liable to be marred by these unsightly flux markings. Apart from appearance, these inclusions are likely to injure the mechanical properties of the metal, and to be a very fruitful source of local corrosion.

It is of the utmost importance that the foundryman shall be completely satisfied that the metal he is purchasing is really "flux free," or that, by his experience of his various sources of supply, he knows that such is the case. In his own interests, the foundryman must make this an important point.

This intensely local "pock-mark" corrosion of castings, due to the presence of deliquescent flux on the surface, must not be confused with the ordinary atmospheric corrosion from which magnesium, in common with nearly all metals, suffers. A bright, clean surface much whiter than with similar aluminium alloys can be obtained from magnesium alloys cast into sand or chill mould, if proper precautions are taken and the advice given in this Paper followed. Such castings will keep this surface for some considerable time, but gradually, if left on one side, a very thin greyish film, the result of atmospheric oxidation, will cover it. This film will be quite firm and not inclined to rub off; it will act as a protective coating against further corrosion. As with iron and aluminium, it is inadvisable to make castings in magnesium alloys that have to withstand immersion in water, unless the castings can be suitably protected from water corrosion. In the case of magnesium alloys, this applies especially to salt water.

Safety of Magnesium.

It is perhaps unfortunate that magnesium is familiar to the world at large chiefly in the form of powder and thin ribbon. This is an opportune moment to confute the idea that magnesium alloys are in grave danger of being set alight with ease. It is certainly true that, given a sufficient supply of oxygen, magnesium powder can be set on fire. Incidentally, given a sufficient supply of oxygen, aluminium powder has been the cause of some terrible explosions; iron filings, too, are readily burnt.

There are two conditions necessary for the rapid burning of magnesium. The first of these is that the metal must be at a temperature at least as high as its melting point. Secondly, that the metal must be supplied with plenty of oxygen. Obviously, these conditions can be readily fulfilled in the case of magnesium ribbon. A match applied to the end of the very thin strip supplies sufficient heat to cause a little of the metal to melt, while, owing to its elongated shape, there is a free access of air. This causes the rapid burning of the metal, accompanied by the well-known white light and great heat. The heat developed is more than sufficient to melt the adjacent piece of the strip, which, in burning, liberates yet more heat, and so on.

* A paper presented to the International Foundry Conference in Paris, on behalf of the Institute of British Foundrymen.

It is quite obvious that these conditions are not so easily complied with in the case of a casting. To commence with, magnesium is a singularly good conductor of heat, so that great heat supplied at one spot tends to be distributed quickly throughout the mass of the casting. Moreover, if an intense local heating causes one portion of the solid mass of the metal to melt, the crust of oxide formed by the burning tends to prevent oxygen from reaching the metal behind it, apart from the fact that the heat developed by the burning of the small spot is rapidly conducted throughout the mass of the casting. After all, if sufficient heat is supplied to the magnesium casting, it will melt, and, as molten metal, it is useless for engineering purposes. No sane man would therefore cause magnesium castings to be used in such positions as would render them likely to be melted while performing their normal functions.

To anyone who has had even a small experience of handling magnesium, these remarks about burning must have been unnecessary. It is surprising, however, how these misconceptions persist. It is amusing to note that less than three months ago, at an international air congress held in London, a distinguished metallurgist of world-wide repute solemnly warned the conference against the use of magnesium alloys on the grounds of their inflammability.

Magnesium in the Steel and Brass Foundries.

Magnesium, with its great affinity for oxygen, is sometimes used as a deoxydiser for brass and steel. The quantity used in each case is extremely small, something in the nature of 0.02 per cent. Care must be taken to see that the magnesium, usually in the form of 1-in. stick, is pushed well down below the surface of the molten metal, so that it does not burn away wastefully on the surface. It is not desirable to use such a quantity of magnesium that much is left over from deoxydising the brass or steel to form an alloy.

The Melting of Magnesium.

Magnesium should be melted in iron or steel pots. As magnesium does not alloy with iron to any appreciable extent, it is not necessary to coat the pots, as would be the case with aluminium alloys. The use of graphite pots in melting magnesium is not to be recommended, owing to chemical interactions resulting in contaminated alloy and "short life" for the pot.

There are many important points to be noted with regard to the melting of the metal.

The free access of air to magnesium or magnesium alloy, and the continual exposure of fresh molten surfaces, are conditions favourable to the production of nitrides and oxides. The presence of either of these compounds in a casting, even in small quantities, will have a detrimental effect upon the physical properties of the casting. It is essential, therefore, that means shall be taken to prevent the formation of these harmful compounds.

An old method of doing this was to melt the metal under a chloride flux. This flux was formed of varying proportions of the chlorides of sodium, potassium and magnesium, sometimes with the addition of a small quantity of potassium fluoride. Using ordinary care and such a flux magnesium may be melted, alloyed and cast with practically no burning at all. Unfortunately, when metal melted in this manner is cast, it is almost impossible to prevent small drops of the molten flux from entering the mould with the liquid metal, and so contaminate the casting with flux inclusion. These inclusions, containing a high percentage of magnesium chloride, are deliquescent. They are fruitful sources of local corrosion and loss of strength.

As manufacturers of the ingot metal have been at considerable pains to produce a metal free from chloride inclusions, it would seem that such a method of melting negativates their efforts. The foundryman is therefore recommended not to use this method, but rather to adopt the procedure which is about to be explained.

For the sake of example, let it be assumed that it is desired to produce castings in a magnesium alloy of the following composition:—6 per cent. aluminium, remainder magnesium.

Practical Points.

The melter should take a pot that is perfectly clean, and place a small quantity of magnesium in the bottom of it. He should melt this magnesium, taking care that the temperature of his metal does not rise more than a few degrees above the melting point. During this process of melting, a tightly-fitting lid should be kept upon the pot. The quantity melted, in this first operation, should be sufficient to fill the pot about one-quarter full when liquid. Fresh lumps of the solid metal, previously warmed, should then be dropped into the molten pool, at such a rate as will allow the metal in the pot just to remain melted. Finally, the calculated quantity of aluminium should be added to the melt, and the whole be stirred sufficiently vigorously to ensure a uniform mixture. During the melting a tightly-fitting lid should be kept upon the pot, and only removed for the purpose of adding fresh metal, stirring, etc. These operations should be done in the shortest possible time. If the temperature of the metal is so regulated, its rise in temperature guarded against by pyrometric observation, and air, as much as possible excluded from entering freely the top of the pot, the alloy can be made up with but a very slight amount of burning.

The temperature of the metal at the moment of casting should be as low as is consistent with the filling of the mould and the demands of "feeding." This temperature is not definite for any particular alloy. It depends upon the type, temperature and intricacy of the mould. Naturally only experience can determine what this temperature should be in any particular cast.

When the metal is melted and the alloy made up, a certain amount of oxide skin is inevitable. This skin must be removed by skimming immediately before casting. It is the author's experience that the alloy should be cast directly from the pot, and not ladled. This means that the amount of metal melted should be sufficient only for the particular work in hand. If a number of small castings have to be made, a small pot should be employed, so that the pot itself becomes, in effect, a ladle.

Melting Equipment.

In order that the temperature of the melt may be controlled with ease, a few remarks about the best type of furnace would not be out of place. It goes without saying that the amount of heat developed by the furnace must be subject to rapid control. Such control is, undoubtedly, most easily obtained in electrically-heated furnaces. Unfortunately, we have yet to be convinced that electric melting of metals is universally the cheapest method. Very accurate heat control can be obtained by suitably designed gas- or oil-fired furnaces. Possibly the best type of gas-fired furnace is the one employing natural draught, as a very "even" heat is then obtained. The "injector" type gas-fired furnaces are apt to be very local in their heating.

It is the author's opinion that coke-fired furnaces are not very convenient for the melting of light or ultra-light alloys.

From what has been said, it is obvious that the ratio of the surface of the molten metal exposed to the air, and the volume of the liquid metal in a pot should be a minimum, in order to lessen the chances of burning. The pots used in the melting of magnesium alloy should, therefore, be designed to ensure the minimum. They should be long, and narrow in proportion.

Casting in Chill Moulds.

It is necessary to cast magnesium into billets, bars, and slabs, as a preliminary to work being done on the metal. Such castings are usually made in chill moulds. The design of these moulds is not radically different from the design of moulds for similar aluminium castings.

When pouring into such moulds, it is good practice to prevent the molten magnesium from striking on the side walls, otherwise serious cold-shutting and skin-folding will result, rendering the casting unsuitable.

The whole art of rolling magnesium depends entirely upon the production of a sound slab in the first place. Much effort has been expended

upon methods to ensure such soundness as a matter of course. A conclusion arrived at is that the only way in which to guarantee good slabs is by bottom pouring. With a bottom pouring method the temperature of the "chill" would assume great importance. In fact, it ceases, strictly speaking, to be a complete chill, especially when, as is necessary in some cases, the mould has to be heated to 400 deg. C.

Test-bars, cast in bottom-pouring moulds, heated to such a temperature, gave figures on test not far removed from those obtained from bars in sand moulds.

TABLE I.—*Mechanical Properties of Magnesium as influenced by Casting Methods.*

	Pure Metal.		Alloy 6 per cent. Al.		Alloy 8 per cent. Zn.	
	M. S. Tons. Per sq. in.	E. Per cent.	M. S. Tons. Per sq. in.	E. Per cent.	M. S. Tons. Per sq. in.	E. Per cent.
Chill cast ..	7.9	4	11.5	5	10.8	3
Bottom poured	7.3	5	9.4	5	9.5	4
Sand cast ..	6.8	5	8.9	7	9.1	4

It would seem unlikely that magnesium alloys are suitable for pressure die-casting. Very excellent results have been obtained, however, from casting the alloy into complicated chill moulds. Such a method is sometimes called "die-casting." A very excellent finish is obtained in

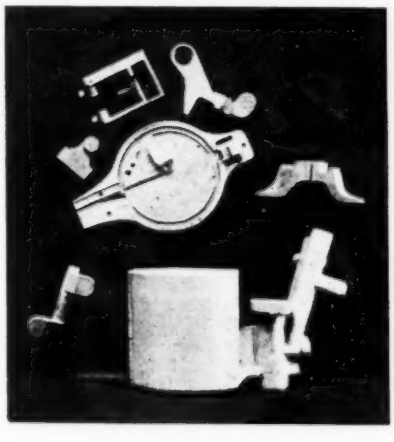


FIG. 1.—CHILL CASTINGS IN MAGNESIUM ALLOYS.

no way inferior to similar castings made in aluminium alloys. The design of the die or chill mould follows rules generally to be observed when designing moulds for magnesium alloys.

Casting in Sand Moulds.

It is only of recent years that castings in sand moulds have been made regularly in magnesium alloys. This was, no doubt, due to the general state of the magnesium industry, and not to any particular difficulty in sand-casting the alloys.

It is obvious that while casting in permanent chill moulds is a very suitable method to use with magnesium alloys, the majority of castings required do not permit of the use of such moulds, either from the reason of complication or expense. Castings obtained by using sand moulds are very satisfactory.

Every metal has its own peculiarities in the foundry, and magnesium is no exception to this. The special conditions obtaining in a foundry devoted to the production of cast iron are not likely to render that foundry extremely suitable for casting of magnesium alloys. On the other hand, aluminium foundry practice will only require adaptation in certain details. These details are ones of treatment rather than lay out.

Magnesium and Dampness.

At high temperatures magnesium interacts very violently with water, and gases are evolved. It should, therefore, be the very earnest endeavour of the foundryman to keep molten magnesium and water as far apart as possible. For example, while the metal is liquid in the pot, anything that is brought in touch with it, such as fresh metal, stirring rods, pyrometer ends, etc., should be rendered free from moisture before being placed in the already molten magnesium. It is common sense, therefore, that when the metal is to be cast, precautions shall have been taken to render the mould and cores dry and free from water in any form.

The mould, etc., may contain water in more than one way. The sand may be damp with rain or added water, or the sand may contain constituents which have "combined water" in them chemically combined.

If the mould and cores are baked thoroughly the water that is mechanically mixed with the sand can be driven off. It is surprising how long the baking takes, and only experience, and sometimes "trial and error" methods, will tell how long any particular mould requires heating.

It is the author's opinion that coke-fired drying ovens are preferable. When gas-fired ovens are used, it is of the greatest importance to see that very perfect combustion of the gas is obtained as only then will perfectly satisfactory results be obtained. With incomplete combustion curious blowholes appeared on the surface of the

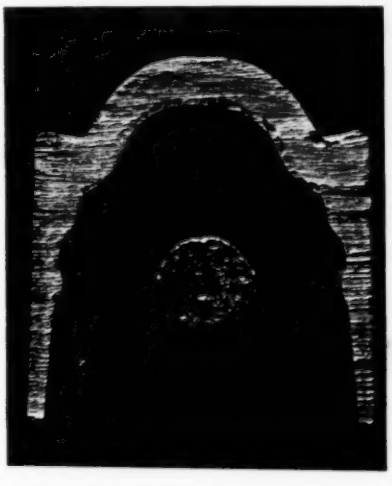


FIG. 2.—SHOWING BLOWHOLES IN A MAGNESIUM PISTON DUE TO INCORRECT STOVING OF THE CORE.

casting. Such holes are shown in Fig. 2 on the inside surface of the piston. The mould was dried in a coke-fired oven, but the core was dried in an oven fired by gas. The temperature of the core oven and the length of time during which the core was baked made quite certain that the core was dry. A probable explanation is that, owing to incomplete combustion, the small quantity of hydrocarbons present in the town gas supply was condensed on the core and not burnt off. However, this matter, which has been a source of much trouble, is still under investigation. The present opinion is that it is preferable to use coke-fired ovens, which have already given good results.

Fig. 3 is a photograph of a section of a solid cylindrical block of 5 in. dia. The blowholes are due to insufficient drying of the mould. With comparatively large blocks of metal, which after casting are likely to remain molten for some time, the mould-drying process should be carried on for some considerable time.

The type of sand to be used in magnesium founding is a very important factor in the production of good castings. The percentage of clay in the sand should be very low indeed. This will keep the "combined" water element down. The sand should be of a very open porous type,

so that the gases formed during the process of casting can be conveyed away easily. While this is a necessary condition of casting with all metals, it is of extreme importance with magnesium.

Sand for Magnesium.

A very high silica sand is to be recommended in core making. Any of the ordinary core oils can be used as a binder. There is a field for much research work in the determination of the most suitable sand to use in the production of magnesium casting. The answer may be supplied by some naturally occurring deposit. Quite possibly the best sand to use is some artificially prepared mixture starting with a basis of pure silver sand.

Magnesium being such a chemically active metal, especially in the molten state, it is of the utmost importance that, while liquid, it is brought into contact with materials with which it may react, for so short a time, that no observable effects are produced. It is essential, then, that the chilling effect when the metal is cast shall be a maximum, so that the metal shall be in contact with the sand of the mould for as short a time as possible while it is molten. It has been found, sometimes, in foundries with which the author is connected, that there is difficulty in producing a certain casting in magnesium alloy. In such cases it has been found on occasions that at places of large section, the metal has remained molten sufficiently long to attack the sand, and there produce a surface on the casting in every way undesirable. It is usually found that the introduction of iron chills in the

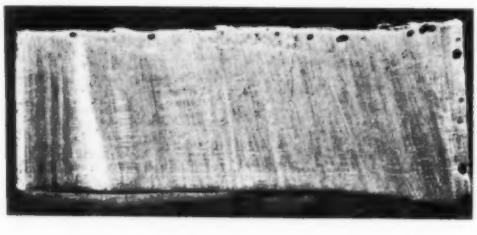


FIG. 3.—SECTION OF A 5-IN. SOLID CYLINDRICAL BLOCK SHOWING BLOWHOLES DUE TO INSUFFICIENT DRYING OF THE MOULD.

mould near these places of large section help to reduce, and finally do away with, this chemical attack.

Design.

The very important questions of design of castings and moulds have not always received that attention from engineers which is urgently needed. This is not the occasion on which to go into the general question of mould design. It is sufficient to say that with magnesium these questions are of great importance. Every metal or alloy has its own particular virtues which recommend it to the notice of the engineer for a particular purpose. It usually has, as well, little peculiarities which call for the use of much skill on the part of the foundryman. He who is responsible for the engineering drawing of the finished product must bear these points in mind. He should be determined to take advantage of these natural assets of the particular metal in arranging out his detail, at the same time making allowances for the shortcomings of the metal. Moreover he must make his drawing so that the foundryman can design the pattern, and core box in such a manner as will facilitate the speedy and successful production of castings.

An illustration with magnesium alloys will perhaps make this clearer. If Fig. 4 is referred to it will be seen that the piston has failed in practice owing to a hole being burnt through the top of it. This was a great pity as the casting was a particularly good one, one to which the photograph does no sort of justice. Here is a case where the foundryman had succeeded in making a really fine product. This product failed through no fault of casting or of the properties of the metal, but rather, with all due respect, to unsuitable design.

Such a design does not take advantage of the very superior heat conducting properties of this particular magnesium alloy. The designer was dealing with an ultra-light alloy. He could have increased the thickness of the piston head to at least 50 per cent., and still left his piston considerably lighter than a similar piston in aluminium alloy. He would moreover not only have increased the strength of the piston head, but he

FIG. 4.—SHOWING A PISTON WHICH FAILED, DUE TO DESIGN.

would have improved its capacity for heat conduction as well. Then he would take advantage to the full of these valuable properties of the alloy.

It is as well when designing moulds for magnesium alloys to remember the simple laws of hydrostatics. Magnesium alloys are more than four times as light as iron. Therefore, it will require a column of molten magnesium four times as light to produce the same pressure as a similar column in molten iron. This point must be borne in mind when designing runners and risers.

Conclusion.

It may be fairly said that provided the metal supplied by the manufacturer is of suitable quality, there are no great difficulties with magnesium alloys in the foundry.

Magnesium foundry practice is based on the broad general laws of all foundry practice. It is only in the details of lay out and manipulation that differences occur. No special plant is required for magnesium foundry work that is what makes such a paper as this so difficult to prepare! There is so very little to say. A common sense appreciation of the chemical and physical peculiarities of the metal is all that is required.

The Author wishes to express his thanks to the directors of the Magnesium Company, Limited, for permission to present this Paper.

Large Orders for Skoda Works from the Far East.—It is reported that the Czecho-Slovak Skoda Works have secured orders involving several millions of C. S. crowns for Japan, Korea, and China. (Current exchange rate 155 C. S. crowns to the £ sterling.)

American Tariff Inquiry into Pig-Iron Costs.—The investigation by the Metals Division of the Tariff Commission of pig-iron production costs in the United States has now been completed. This work, it will be remembered, was taken up through the application of Eastern merchant blast-furnace interests for an increase in the import duty of 75c. (3s. 4d.) per ton on pig-iron under the flexible provisions of the Fordney-McCumber Act. The agents of the Commission, acting under Mr. Paul M. Tyler, chief of the Division, through questionnaires and personal investigation, visited virtually all the merchant furnaces in the various sections of the country. They will now compile the data obtained, and later it is expected to make an investigation in pig-iron producing countries of Europe, as already announced. The unsettled conditions in Europe, however, make it uncertain when the trip abroad will be made.

XUM

Training Foundry Apprentices at the Falk Corporation.*

By H. A. Frommelt, Milwaukee, Wis.

No one who has passed through the past decade or two of American industrial history needs to be reminded of the tragic situation that exists as regards the lack of skilled craftsmen in the metal trade industries. The war, quite naturally, accentuated this lack, and now after two years of business depression, when trade is again on the up grade, it is more than ever apparent that productive capacity is seriously curtailed owing to a lack of skilled productive help.

There is no question, then, of the need of a training programme designed to furnish this skilled productive help. There may, however, be some question with regard to the nature of this training programme, especially the length of time.

There seems to be a tendency in more than one quarter to rely on a period of training less than the old traditional four-year standard. Here and there vestibule schools, training quarters, and specialised educational departments have been installed with an attempt to turn out a sort of hot-house product. But we are only intriguing ourselves into believing that such products are suited to our needs. Two-year apprenticeships are also being tried in the hope that this will provide a remedy.

The ideas back of this specialised programme need only to be examined briefly to discover their fundamental weakness. The arguments used as a basis for these training programmes run something as follows:—

The newer methods of education, text books, close supervision and up-to-date physical equipment make it possible to train men much more rapidly than in the old days when these were lacking. That this is but a half-truth becomes apparent immediately if we stop to consider how much more the craftsman of to-day need know to become skilled than the craftsman of old. How much, for example, has the whole science and art of the metallurgy of iron and steel, their heat treatments, and alloy making, grown in the last decade? How much of this should a good craftsman in the steel industry know and appreciate to become thoroughly skilled? True, there are not many at the present time among the few remaining skilled mechanics who do know and appreciate these things, but if the foundry art is to keep step with the other departments of our manufacturing industries, it is certainly true that each craftsman in his department should, and must, know and appreciate besides, the new developments in the science of metals. Unless they do, we certainly cannot hope to draw from among their number men who can act in an executive capacity.

Four Years Training Necessary.

Now, if we are to train men who are thoroughly capable in the art, considered as a whole, it is surely obvious that we must train them for at least four years. It is true that we can take the average individual during his learning years and teach him to make a certain mould or class of moulds within six months or a year, or thereabouts. But to take the same individual and give him such a training that he knows not only how to ram the sand around his pattern, but also knows and appreciates the materials he is handling —sand, steel, etc.—it certainly is patent that four years is only too short a time. Anything less than this becomes a training programme not for fully-fledged, all-round workmen, but simply specialists in this or that small department of the foundry.

Essentials for Successful Training.

The author has grouped these elements under three distinct heads, which are as follows:—

First—It is necessary to have a plant and a product of such quality that pride of craftsmanship can be taken in them.

Second—It is necessary to have capable general and departmental executive organisations.

Third—It is necessary to have an adequate apprentice or training organisation and programme.

To elaborate briefly, it is clear upon a little consideration that it is futile to consider a training programme of the kind we have in mind unless the product, and the plant making the product, are of such nature that the workers themselves can find that satisfaction in the work which is of necessity a characteristic of the true craftsman. Not only must the product be sufficiently varied, but the quality of workmanship demanded must be such that it will not violate the true ideals of craftsmanship.

It follows from this quite readily that a second very necessary characteristic is capable general and departmental executive direction. An organisation of this kind must thoroughly appreciate the necessity of a training programme. If the executives were solely imbued with the idea of production and production only, and were incapable of appreciating the equal necessity of craftsmanship for that production, training programmes would be of short life in an organisation of this kind. From the second necessary characteristic follows the third, quite obvious also.

There must exist an apprentice or training organisation in this ideal plant, which we are considering, that will be of equal importance with the production phase of the business. This apprentice organisation must be thoroughly capable of training a sufficient number of men as craftsmen in the various trades of the plant. These three factors must, under ideal conditions, interact noiselessly and smoothly. If they do, production, which is the ultimate aim of any manufacturing business, will go on uninterruptedly, never experiencing a dearth of competent craftsmen.

Classification of Apprentices.

These ideas have served as a basis for the training programme put into effect in the plant of the Falk Corporation, which has a more or less general manufacturing engineering business, specialising, however, in helical gears and railway castings. We employ skilled workmen in the machine, foundry, and pattern departments. It was necessary, therefore, in instituting a training programme, to make it sufficiently broad to cover these essential trades. The programme, however, has been extended sufficiently to cover five essential divisions and two auxiliary branches or divisions. The five divisions run as follows: Machine division, steel division, pattern division, design division, and operating division. In addition to this, apprentices are employed in small numbers in the electrical and sheet metal departments.

It might be well at this point to explain reasons for this particular classification. As all who have experience in foundry work know, there is a deep traditional feeling existing in opposition to the moulding trade. It probably comes to us from the days when each moulder in special shoes and with his legs swathed in gunny sacks, poured his own metal. The dangers involved gave rise to a feeling of hatred against anything that had to do with moulding. This even took hold of the educational system and of the medical profession to such an extent that our education authorities treat with silent contempt the entire basic industry of iron and steel, and many of our doctors are only too ready to help the exodus of skilled workmen from the foundry with a certificate of illness due to alleged injurious effects of foundry air and surroundings.

Considering all this, the firm came to the conclusion that it was better to combat this, partially at least, and for the time being, by giving the whole foundry business a new label. This was done by regrouping all the metal trades under the general heading of "Engineering Trades," as indi-

* A Paper presented to the Cleveland meeting of the American Foundrymen's Association.

cated above, and the foundry then comes under the steel division. (In the case of a grey iron foundry, the classification would probably be "iron division.")

Schedule of Work Outlined.

Referring to the five main branches enumerated above, it should be remarked here that a definite schedule of work has been laid out under each. Thus, the machine division includes machine and bench work, erecting shop work, and, in some cases, special work, such as heat treating and machine estimating. These divisions are not hard and fast. Thus a young man who shows particular adaptabilities will be given suitable experience.

Coming more specifically now to the steel division, there is in general five divisions—moulding, core making, heat treating, furnace milling and steel testing, inspection, etc. Each young man indentured in the steel division will normally pass through these five branches. Here and there a young man may be sent to a grey-iron foundry for cupola experience, or to a grey-iron foundry for experience in iron castings.

The pattern division is obvious, without further explanation, particularly as there are no definite branch divisions. A design division, however, consists of one year of shop work, either machine or foundry, or both, and two years of apprenticeship in the draughting and design department. The operating division includes three years' definite training, one of which is given over to machine-shop work, the remaining two to experience in both the boiler and engine rooms of the power plant.

Class Instruction.

There is, in addition to the definite schedules of work laid out in the shop, an equally definite schedule of school work laid out, which is designed to supplement the actual work in the various departments. Wisconsin's apprenticeship law requires a certain amount of school work under prescribed supervision; in the firm's case, in continuation schools. It was felt as soon as the concern had entered upon this training programme that some of this school work should be undertaken by the company itself. The close contact thus established between the apprentice boys and the company apprentice organisation was felt to be of so much value that it could scarcely be sacrificed even at the cost of an additional hour or two of school time. Subsequent events have proved the validity of this supposition. There is thus established a close and intimate contact with each individual apprentice, such that enables the company to maintain a well knit and well organised apprentice group.

Domestically this school training is referred to as "Related Shop Technique." The idea is thus quite well expressed, namely, that the technical information given to the boys is such as is necessary for the work that they are actually doing in the shop.

The firm have established connections with the continuation school in such manner that the work given in the company class room is merely supplementary to that given by the continuation school itself, and taken as a whole presents a well-formed programme. Thus there is no overlapping nor reduplication.

Referring specifically to the programme laid out for the apprentice in the steel division, it may be of interest to know that the school work comprises instruction in the mathematics required for a good craftsman in that division in blue print reading, in shop sketching, in the metallurgy of the materials that they are handling, the composition of the sand, and other moulding materials, and the technical data that are necessary for manual operations in the actual moulding work.

This complete training programme, consisting of the work in the shop and in the class room, is such as to train fully equipped skilled men. In addition to the programme of school training laid out in conjunction with the continuation school, this company has entered into an agreement with the International Correspondence Schools whereby a number of apprentices are enrolled with this school in courses adapted to their special needs. The time for study is given by the company, amounting to five hours per week, with private instruction and help from the apprentice organisation. Entirely special courses are occasionally laid out, such as, for example, a production course for young men who are likely to be used later on as foremen or executives. Here again an attempt is made to keep the whole programme as elastic as is necessary for individual needs rather than to make it a series of cast-iron compartments into which individuals are squeezed.

Four years is, if anything, entirely too short for this programme. It is sufficiently comprehensive to produce well-trained men from amongst whose numbers the firm can choose men competent as foremen and executives. In addition to this it is obvious that it will provide an entirely sufficient number of well-trained skilled men.

Schedule of Rates.

It may be of interest to refer to the schedule of rates and grades of apprenticeship in each department. The basic apprenticeship consists of four years in all departments. Credit, however, is given for any school work over and above the grade school. Thus one year credit is given to a high school graduate, making his apprenticeship three years. An additional year is given to a university graduate, making his apprenticeship two years. The vast majority of apprentices, however, are indentured at the age of 16, the minimum age in Wisconsin. It would only seem quite fair and just to a young man four years older, and who had four years of training given in a high school, to credit him with at least one year on his apprenticeship.

These, in the main, constitute the principal grades of apprenticeship in these departments. The rate for the regular four-year apprenticeship is indirectly set by the industrial commission. In Wisconsin the machinist and patternmaker apprentice rates start at 9d. an hour. In the foundry the grade school apprentice starts at a rate 25 per cent. higher. This has been set and agreed to by the local metal trades, and then sanctioned by the industrial commission. The high school rate begins at 1s. 5½d., and increases every six months during the three years by penny increments. The university rates begin at 1s. 10½d., and increase every six months up to 2s. 3½d. at the last six months of a two-year period.

It may be well to emphasise again that the various divisions as regards schedule of work referred to above are not necessarily inflexible, but admit of even considerable change as circumstances demand. In other words, the idea is not to make a young man fit into a definite compartment or division, but rather to make the experience suit his particular needs and legitimate desires.

While no programme of this sort can be said to be definitely and finally successful unless it has graduated trained skilled men who have remained with the organisation, yet we have gone on sufficiently to be able to warrant the belief that the essentials of the programme are fundamentally correct. There are at the present time about 110 apprentices among a total number of employed of about 1,200. There are about 40 apprentices in the various grades mentioned above in the foundry.

Factors which have made Training a Success.

The factors which have tended to make a success of this programme might be considered under eight different heads; the first of these, and probably the foremost, is proper apprentice supervision. This must be embodied in a man who has had sufficient background, along with technical and practical training, to lay out a well co-ordinated programme, not only in the shop, but in the class room as well. It is necessary, of course, that he be able to adapt himself to the existing organisation without causing undue friction, and also that he have no little insight into the character and even eccentricities of youth. The second essential factor follows directly from this, namely, close supervision by a person in the organisation not responsible for production. The apprentice department must never be hampered with the demands of production. It must be entirely free to play its own game within reason

over and above the production side of the business.

In the third place must be mentioned the close co-operation that must exist between the parents and the apprentice organisation, and through it with the company. Modern industry with its mammoth plants and large organisations has built by its very nature an invisible barrier around itself, separating it effectively from the hearts and the homes of the men who make up its human element. And yet, there is nothing so essential to the success of apprenticeship as close co-operation between parents and the company. Both must be vitally interested in the training of the boy, and yet how can this be possible unless some special means are taken to break down the barrier that exists.

The apprentice organisation must take upon itself the task of gaining the sympathies and interests of the parents in this problem, and to accomplish this in our case the firm has seen fit to devote a large portion of its time to visiting parents, inviting them to visit the plant, and to establish a monthly connection through records of their son's progress in shop and school. This should be emphasised as making up one of the largest factors in the success in this programme.

The fourth essential factor is the necessity for definite records; that is, such records of shop and school work as will enable the apprentice organisation to shift apprentices from one class of work to another at the proper time, to grade their shop and school work for purposes of classification and reference, and finally for such records as will be necessary later in making up a report of a man's fitness for a certain job.

In the fifth place it is necessary to emphasise the necessity for an adequate training programme in each department. The foundry training programme should be of such nature and so presented to the prospective apprentices that they will see the immensely interesting future that lies ahead of them. This is in addition, of course, to the demands coming from the needs of properly trained men.

The principle of reward should also be recognised as an essential factor in any training programme. By this is meant a system of awards or prizes set up in each department which will put the various classes of apprentices in competition one with the other and thus bring out their very best efforts individually. This was done in each department in our plant. Three prizes—first, second and third in addition to a general plant prize to which all were eligible, were set up.

If apprenticeship is to be successful in an entire district, not only in isolated plants, a real spirit of co-operation must exist between the various plants in that group. The smaller plants will be unable to pursue a training programme such as has been here outlined. For this reason the member plants of the Milwaukee metal trades group have combined in such manner for the purpose of such training that the smaller plants, machine shops, foundries, etc., can send their apprentices to the larger plants to complete their training and have the advantage that a comprehensive shop and school course such as the smaller plant would find uneconomical. This is an actual operation, and has proved itself an essential factor in the success of apprenticeship in this district.

As a final factor, which is really corollary to the one last mentioned, it has now become obvious that a training programme, if it be successful at all, must be sufficiently comprehensive to invision the needs, not only of an individual plant, but of an entire district. To accomplish this the member plants must enter into a whole-hearted spirit of co-operation and have faith in one another to the end that they are willing to exchange apprentices, training, and experience.

It is essential that we comprehend fully that foundry apprenticeship is not only possible, but can be made decidedly successful, providing only we realise the difference between the industries of to-day and those of old, and are willing to adapt our training programmes to the changed conditions. We can secure for indenture sufficient young men for our needs. It is frequently said that the young men of to-day are different from those of an earlier generation. This is probably true, in the accidental characteristics at least, but fundamentally they are just the same, and if we can duplicate the apprenticeship of 50 years ago, when the master was president, general manager, foreman and craftsman, and bring the same intimate relationship to bear between the company and the young learner as in those days, in addition to providing him with an actually adequate opportunity for learning the trade, we shall have no trouble in making this apprenticeship thoroughly successful.

Oxygen Lance for Breaking up Skulls.

Many iron and steel plants have tons of valuable metal in the form of skulls and spills, often the accumulation of years, which are worthless unless they can be remelted. These are generally too heavy and bulky to break in the regular way with the drop-ball. They can, however, be economically salvaged by the oxygen-cutting process. Occasionally the problem of reducing these masses of metal to charging-box size is solved by drilling holes and blasting. This method, while it serves the purpose in a fairly satisfactory manner, is not a practicable one from a cost standpoint, since the value of the time and labour necessary to reduce a skull to the proper size in this way often exceeds the value of the metal reclaimed.

The use of the oxygen lance in the opening of frozen tap-holes, and in drilling large salamanders when it is necessary to remove them in the shortest time possible, is a well-known application which is used extensively in every iron and steel producing centre. Among American plants which have recently found it advantageous to go a step further than this is a southern steel plant where the oxygen lance is now used for drilling holes for blasting to reduce skull scrap to charging-box size. The method of doing this work, according to an article in "The Blast Furnace and Steel Plant," is to heat a spot on the skull to a bright red with an oxy-acetylene welding blowpipe, or to place a cube of steel heated to this temperature on the skull. Oxygen under comparatively high pressure is then directed against the heated spot or the red-hot cube of steel through an iron or steel pipe of suitable diameter, usually a ¼ in. The oxygen actually burns or cuts the metal of the skull, and the pressure of the oxygen blows away the resulting slag as it is formed, thus drilling the hole. During the process, the pipe through which the oxygen passes is gradually consumed; the heat generated by the combustion of the pipe aiding in drilling the hole. The burning of the pipe aids especially when slag pockets or sand holes are encountered. Sometimes, however, these are of such size that the drilling is temporarily interrupted. In this case a red-hot rivet shank or similar piece of metal is dropped into the partly-drilled hole, and when the oxygen jet is directed against this, the added fuel furnished by the metal introduced, generally carries the hole through the obstruction.

An interesting variation from the usual straight lance, fed down vertically through a tripod, is used in the southern plant mentioned. The lance is made of two sections of pipe, coupled together at right angles. A lance of this type permits the operator to take a position far enough from the hole being drilled properly to observe the work, unhampered by the smoke and sparks. The oxygen is furnished from cylinders connected up with a manifold, and a high-pressure hose is used on the oxygen line from the regulator to the lance. The use of the manifold assures a sufficient volume of oxygen for the work and prevents freezing. Drilling skull-scrap in this way, two men can do in a few hours the work which will require by the old methods the services of five or six men for several days.

MR. J. M. ESPANA has been elected the vice-president for Spain of the Association Technique de Fonderie. Mr. Espana is a director of Messrs. Bonvillain et Ronceray, of Choisy le Roi.

XUM

Shipping, Engineering and Machinery Exhibition at Olympia.

Notes on the Exhibits.

The Exhibition, which will remain open until the 22nd inst., is certainly more representative of the interests concerned than was the Exhibition held a year ago. The main building is devoted entirely to exhibits of a general engineering character, though on almost every stand are to be found machines or apparatus designed for service on shipboard. The new Hall, a much-needed and valuable addition to the accommodation at Olympia, is taken up with exhibits of motor-boats, marine and stationary internal-combustion engines and accessories. For the most part the exhibits in the Machinery Section are representative of the well-known standard lines of the builders; indeed, there is little of a novel character to be seen. It will therefore not be necessary to enter into any lengthy description of the various exhibits, but suffice it we make brief reference to a few of the leading ones, which have interest for foundrymen.

Oxy-acetylene welding and cutting plants are exceptionally well represented, and a study of the various types of plants shows a remarkable advance over the apparatus exhibited only a year ago.

CARBIC, LIMITED, London.—The feature of this stand is the Carbic portable oxy-acetylene welding and cutting plant. A model glass generator is used to demonstrate the method of producing acetylene from carbide cakes.

THORN & HODDLE ACETYLENE COMPANY, LIMITED, London, include in an exhibit of oxy-acetylene apparatus their "Incanto" generator, shown in actual operation. It is constructed on the water-to-carbide principle, and is entirely automatic in use, generating gas in exact proportion to the consumption. Welding and cutting blowpipes are also shown.

ALLOY WELDING PROCESSES, LIMITED, London, are exhibiting a special type of engine-driven arc-welding plant in operation. The machine consists of a 10-h.p. Gardner engine, 1,200 r.p.m., driving a self-stabilising welding dynamo of the dropping characteristic type, giving an open circuit voltage of 70, which drops to the pressure required across the welding arc immediately the operation commences. The output available, variable by field control, is 50/200 amperes.

G. D. PETERS & COMPANY, LIMITED, London, are demonstrating the Plastic Arc system of electric welding, a single-arc motor generator set being shown in operation. The system embodies the principle of an automatically controlled and regulated current, thus ensuring constant voltage and uniform heat to the weld.

EUREKA CUTTER-WELDER TOOL COMPANY, LIMITED, Manchester, show in the Eureka Cutter-Welder a tool equally suitable for cutting, welding, soldering, etc., for use with all clean fluid fuels, and therefore free from the troubles of carbide and resultant residue

THE BRITISH OXYGEN COMPANY, LIMITED, London.—This exhibit covers the full range of oxy-acetylene injector welding blowpipes, and the oxy-acetylene and oxy-coal-gas metal cutters. Frequent demonstrations are given of metal cutting and welding.

HYDROGEN, OXYGEN AND PLANT COMPANY, LIMITED, London. This exhibit comprises gas generators, gas cylinders, and a full range of accessories for use in conjunction with blowpipes and the like.

ALLEN-LIVERSIDGE, LIMITED, London, show apparatus for oxy-acetylene welding, metal cutting, etc. Acetylene lamps for mining and other duties are also shown.

PREMIER ELECTRIC WELDING COMPANY, LIMITED, London (a constituent company of Nobel Industries, Limited), are showing an extensive range of up-to-date types of electric welding plant and equipment. While their standard petrol-driven generator remains practically without alteration, they have introduced several types of motor-generator plant and alternating-current equipment on entirely new lines. Their multiple-arc D.C. welding plant is particularly worthy of notice. It is designed with a view to supplying more than one operator, and at the same time keeping the characteristic efficiency of the "Premier" single-operator set. The welding generator supplies current at from 30 to 40 volts, and thus has a sufficiently high voltage to enable it to be used with any type of electrode at present on the market. Coupled in series with this generator is a small boosting dynamo which generates current at about 35 volts, the voltage available for striking the arc being, therefore, between 65 and 75 volts. Immediately the welder starts the arc with his electrode a contactor device withdraws the booster and welding proceeds on the main generator. Recognising that the welding transformers at present on the market have an extremely low power factor and hence a very small efficiency factor, the Premier Company have applied the same principle to an A.C. transformer as is used for their multiple-arc welding set. In this transformer the secondary winding is split into two portions, one giving the ready current at 30 volts and the other being in the nature of a booster, and giving a small current output at about 45 to 50 volts. By means of a special contactor device these two windings are in series as long as no current is passing; the moment welding commences the boosting portion of the secondary winding is withdrawn by the contactor gear and welding proceeds on the main winding, which is delivering current at about 30 to 35 volts. A small choker is employed in the welding circuit in order to prevent rapid fluctuations of current, and at the same time to provide a certain measure of current control. The Company's standard 4.4-kw. engine-driven set and their motor-generator set are also being exhibited, and a series of interesting applications of electric arc welding will be demonstrated during the course of the Exhibition. In addition to the well-known standard types of "Premier" electrodes, the new "Premier" high-carbon electrode (0.5 per cent. carbon) is also exhibited.

NOBEL INDUSTRIES, LIMITED, London, have a comprehensive display of numerous products made at their different factories. In a large showcase will be found explosives such as are used for mining, blasting work and civil engineering. The special display of Necol plastic wood is a feature of the Stand, while the new Collodion glossy enamels for spraying metal and woodwork are an interesting development. Edison all-steel accumulators, in which Nobel Industries, Limited, have a large interest, are shown.

JAMES HOWDEN & COMPANY, LIMITED, Glasgow, include in an exhibit of their well-known forced-draft furnaces, and Howden-Burdon oil-gas furnaces, a comprehensive range of valves and boiler mountings, etc.

THE CHEMICAL ENGINEERING COMPANY (MANCHESTER), LIMITED, Manchester, are showing a "KEK" patent centrifugal grinding and blending mill, suitable for grinding, granulating or pulverising a wide range of materials. With its latest adaptations the "KEK" mill is an emulsifier and colloid machine. It can be used for simultaneously grinding and blending materials in a dry, semi-liquid, or paste condition. It has also been adapted for powdered fuel firing of furnaces and steam boilers. On the Stand are also displayed a large number of samples of products which have been actually treated on the "KEK" mill by various manufacturers.

W. & T. AVERY, LIMITED, Birmingham, confine themselves in the main to exhibiting a range of testing machines, amongst which mention may be made of the Universal testing machine of the vertical type and "universal" in character, permitting different forms of test to be made without change of tools. It is designed upon the single-lever principle, the load upon the test-piece

being indicated by a poise weight traversing a graduated scale upon the steelyard. They also show their automobile spring testing machine, the load being applied and reversed by an electric motor, thus ensuring rapidity of testing, consistent with the greatest accuracy. Another exhibit is an "Avery" machine for carrying out the Brinell test, designed throughout on the weighing-machine principle, and ensuring that the specified load is accurately applied and maintained. A further exhibit is a platform machine with a capacity of 10 cwt., size 2 ft. × 2 ft. 6 in., with semi-automatic indicator. Of cast-iron, with machined bearings to take the four corner links, the box is mounted on four cast-iron wheels machined on the periphery to ensure perfectly even tread, and fitted to mild-steel axles, which pass through the holes drilled in the box. On the levers continuous interchangeable high-grade steel knives are fitted, being secured by shanks, spring-lock washers and nuts. In regard to the corner link, it should be noticed that the friction buttons are interchangeable, and the same may be said of the complete link, thus obviating the possibility of inaccurate weighing owing to the links being mixed up when assembling the machines abroad. The legs of the platform are designed so that when placed on the levers they seat themselves immediately in the correct position, giving accurate alignment to the knives and bearings. Fitted with hardened steel knives, the steelyard has a "Delta" metal index bar associated with it, and is notched and marked by an automatic machine designed for the purpose.

GODFREY ENGINEERING WORKS, London, show an ingenious oxygen-jet cutting machine which cuts to any desired shape, using a wooden template as guide.

HANCOCK & COMPANY (ENGINEERS), LIMITED, Croydon, are giving daily demonstrations of metal-cutting by the oxygen and coal-gas process.

THE AUTO-WELDING AND ENGINEERING COMPANY, LIMITED, London, include in an exhibit of coated electrodes and specimens of electric and acetylene welded work, a number of portable grinding and polishing machines which are shown in operation.

THE ANGLO-SWEDISH ELECTRIC WELDING COMPANY, LIMITED, London.—This exhibit comprises a series of test-pieces, showing the results upon specimens of welding by the KJELLBERG system.

HERRING & SON, LIMITED, Chertsey, have an interesting exhibit of castings in iron, brass, bronze, and other non-ferrous metals. The castings shown are of course of a small type, but are all remarkably sharp and clean.

H. C. SLINGSBY, London, shows a selection of trucks in various forms.

BUCKLEY, SAUNDERS & COMPANY, LIMITED, London, have a full range of electric welding machines, all of which can be seen in operation.

ROBERT HEATH & LOWMOOR, LIMITED, Bradford, have on exhibit their new "Silent Record" Semi-Diesel engine, the features of which are the perfect scavenge, no crank-chamber compression, and forced lubrication to all working parts. The distribution of air is controlled by means of a simple piston valve, thus dispensing with all automatic valves.

THE BRITISH ARC WELDING COMPANY, LIMITED, London, confine themselves to exhibiting specimens of the work done by their process.

THE MONOMETER MANUFACTURING COMPANY, LIMITED, Barrow-in-Furness, show the Monometer die-casting machine, Monometer whitemetalling plants for the production of all sizes of bearings, Monometer melting, hardening, and annealing furnaces, patent fuel oil and gas burners, etc.

THOMAS SUMMERSON & SONS, LIMITED, Darlington, have a fine exhibit of high-grade steel castings. Several of the samples are sectioned to show the quality of the steel, and test bars demonstrating the tensile strength and high tension characteristics are shown. On the Stand are also shown samples of high-tensile "Granfin" cast iron—a product of the electric furnace.

METALLISATION, LIMITED, London, demonstrate their process of melting and atomising metal and impinging it in the form of a fine spray as a coating surface upon any metal or substance.

THE CHEMICAL AND TECHNICAL ENGINEERING COMPANY, LIMITED, London.—This firm, who are well known to foundrymen as the manufacturers of "Corebind," have developed and placed upon the market a complete new range of core sand-binding materials. First, there is a straight linseed oil, followed by "Plastol" and "Eknol," both of which are said to have special properties. Another new material is "Vivet," which is offered as a moulding sand-binder and a reviver of used sand.

"Invar" and Related Nickel Steels.

The Director of the U.S. Bureau of Standards has issued a circular giving a compilation of data obtained during the last thirty years by various investigators on the different properties of nickel steels. Particular attention is given to "invar," a nickel-iron alloy containing about 36 per cent. nickel and possessing an extremely small thermal expansivity at ordinary temperatures, the mean coefficient of linear expansion between 0 and 40 deg. C. being on the order of 1 to 2 millionths.

Following an historical account of the development of nickel steels and studies of their properties, the nature of the anomalies in behaviour met with in these steels and characterised by their irreversible and reversible phenomena are discussed in the light of the results obtained on their various physical properties. The constitution and microstructure of these alloys are first dealt with, and next the rather extensive studies made on the magnetic properties.

Anomalies in the change of electrical resistance with temperature are shown to be present in nickel-iron alloys. It is shown by a diagram for electrical resistivity at ordinary temperatures, plotted from data obtained on pure ferro-nickels, that there is a sharp increase in resistance for those alloys containing about 30 or 35 per cent. nickel—the resistivity of "invar" being on the order of 80 microhms-cm.

The anomalous behaviour in the thermal expansion of nickel-iron alloys at various temperatures is well known. It is shown that the degree of thermal expansivity reaches a minimum in alloys with about 36 per cent. nickel (and 0.4 per cent. manganese and 0.1 per cent. carbon), and the position of this minimum may be modified by the presence of added elements as chromium, etc., and also by thermal or mechanical treatment. In addition to the principal characteristics of thermal expansion, there are certain secondary phenomena of a transitory and of a progressive nature occurring over small ranges of temperature or even at constant temperatures over a long period of time which affect the constancy in the dimensions of the "invar." An aging process or special heat-treatment is employed to reduce these secular changes to a minimum. The cause of this instability of nickel steels has been found to be due to the presence of carbon.

Thermal conductivity and specific heat of nickel-iron alloys show minimum and maximum values respectively, at about 35 per cent. nickel.

The tensile properties of "invar" may run as follows:—Tensile strength, 22.3 to 44.6 tons per sq. in.; elastic limit, 13.3 to 31.2 tons per sq. in.; elongation, 25 to 50 per cent.; and reduction of area, 40 to 70 per cent.

Nickel steels present anomalies in the elastic modulus, corresponding closely to those found in thermal expansion. It has been found that the degree of anomaly can be reduced in very large measure by means of suitable additions made to the alloy, namely, about 12 per cent. chromium or its equivalent, this alloy having recently been introduced under the trade-mark "Elinvar."

Resistance to corrosion by fresh and sea water and acid liquors increases with the proportion of nickel. An alloy containing about 18 per cent. may be regarded as practically non-corrodible. The resistance of "invar" to oxidation, while very much greater than that of ordinary steel, is not perfect, and it is therefore advisable to coat an "invar" instrument with a protective coating as vaseline, if it is to be exposed for a long time in a moist atmosphere. (Circular No. 58.)

An Apprenticeship Course in Foundry Practice.—LVIII.

By Ben Shaw and James Edgar.

CUPOLA PRACTICE.—METAL MIXTURES.—II.

The composition scrap is naturally most variable, and consequently it is only possible to give an approximate analysis of what may be expected in ordinary scrap consisting of castings of a general character. The composition of scrap from special castings will more or less compare with mixtures used for similar work, and as it is just as necessary to have the analysis of the scrap as the pig iron, the composition should be determined where there is any question about its suitability for the purpose desired. For the purpose of this article the average scrap may be assumed to have the following composition:—

	G.C.	C.C.	Si.	S.	P.	Mn.
Light Scrap.. ..	3.25	0.25	2.55	0.06	1.20	0.45
Medium Scrap ..	3.10	0.45	2.15	0.08	0.90	0.50
Heavy Scrap ..	2.85	0.55	1.75	0.10	0.75	0.70

In determining a mixture consideration must be given to the design and purpose of the castings to be made. It would be outside the scope of this article to consider the various mixtures and the specific purposes for which they are used, but a very valuable report of a committee dealing with standard mixtures for iron castings was presented by Dr. Porter before the American Foundrymen's Association. In this report the analyses of about a hundred different types of castings were given, and while the composition of American pig-iron varies somewhat from that used in this country, notably in the phosphorus contents, much useful information of suitable mixtures for a wide range of castings is given and a careful perusal of this report would be profitable. For the purposes of this article a suitable chemical analysis for a general range of work will probably suffice. Thus the analysis for different classes of castings, including thin ornamental work, medium-sized castings for general work, heavy machinery castings and engine cylinders or hydraulic work given by F. M. Thomas in a Paper read before the Birmingham Metallurgical Society is of particular interest. The analyses suggested being as follows:—

For thin ornamental work: G.C., 3.20 to 3.60; CC., 0.08 to 0.15; Si., 2.50 to 2.80; S., 0.03 to 0.04; P., 1.30 to 1.50; and Mn., up to 1.0 per cent.

For medium-sized castings for general work: G.C., 3.0 to 3.2; C.C., 0.35 to 0.45; Si., 2.0 to 2.25; S., 0.06 to 0.08; P., 1.0 to 1.3; and Mn., up to 1.0 per cent.

For heavy machinery castings: G.C., 2.8 to 3.0; C.C., 0.45 to 0.60; Si., 1.2 to 1.5; S., 0.06 to 0.08; P., 0.40 to 0.60; and Mn., 0.60 to 0.85 per cent.

For engine cylinders and hydraulic work: G.C., 2.5 to 2.8; C.C., 0.60 to 0.75; Si., 1.0 to 1.3; S., 0.08 to 0.12; P., 0.45 to 0.70; and Mn., 0.50 to 0.70 per cent.

Changes in Composition due to Melting Conditions.

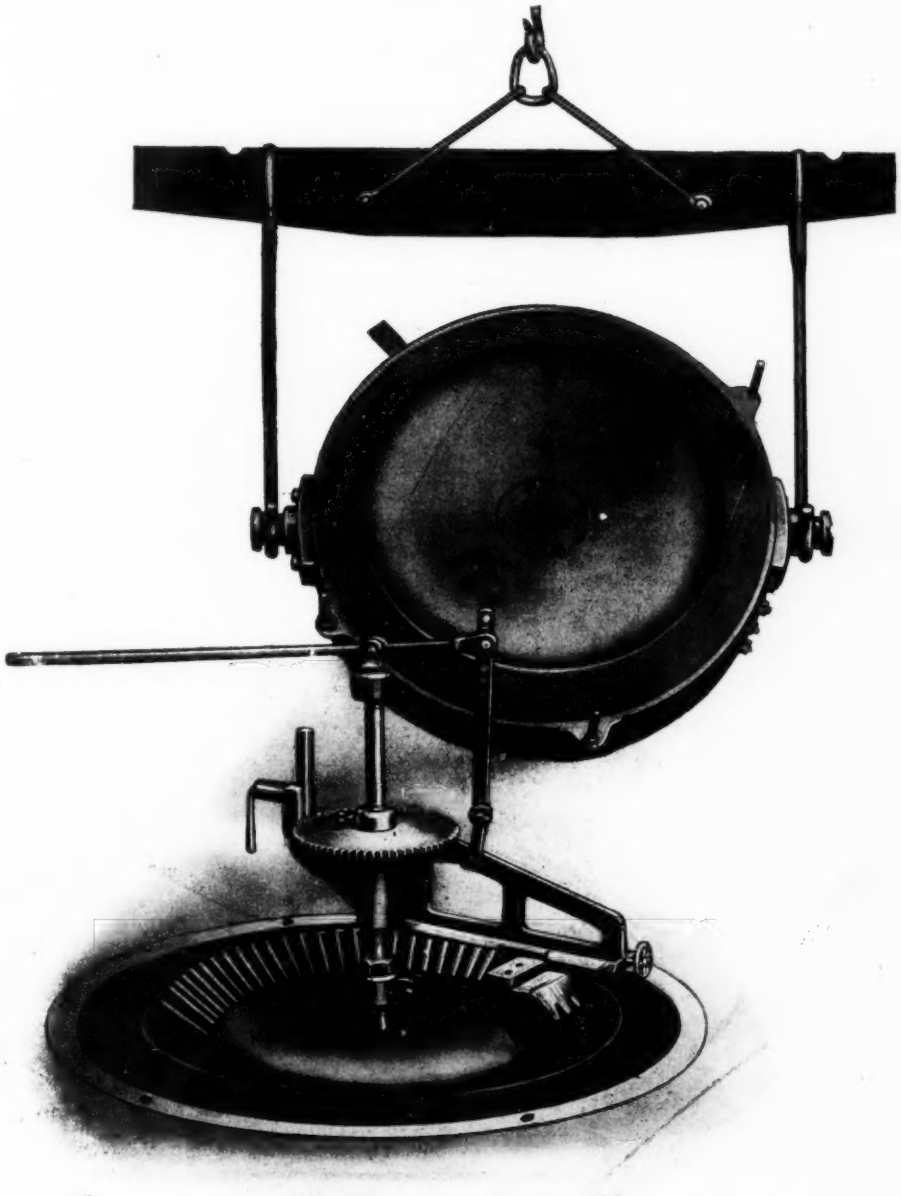
In charging the cupola to obtain a close approximation to a required mixture it is necessary to take into consideration changes that are likely to take place during the time of melting. The analysis of the metal after it has passed through the cupola varies from that with which the cupola is charged. The amount of change varies somewhat according to the speed of melting, the temperature of metal produced, the quality of coke used, and according to the influence of the flux used, consequently only an approximate determination of the changes that are effected can be given. The total carbon contents is not affected as a rule, but when steel is introduced in the charge to form semi-steel, carbon is absorbed. With these mixtures it is customary to increase the manganese content, which increases the saturation point of the iron for carbon. Although the total carbon content does not vary much, the condition in which the carbon is present does vary, but the casting conditions affect its final composition. In contact with carbonic acid gas, silicon burns and raises the temperature of the cupola. It, however, becomes oxidised, which prevents further combustion. There is, therefore, a loss of silicon. This loss varies from 0.15 to 0.25 per cent. of the total silicon contents, but it is customary in calculating mixtures to make an allowance for an average loss of 0.20 per cent. Thus if the estimate or calculation of silicon in the charge is 2.5 per cent., the amount to be expected in the metal after passing through the cupola will be 2.3 per cent. Sulphur is absorbed from the fuel to a certain extent, depending upon the quality of fuel and the kind of scrap used in a charge. The amount likely to be absorbed is influenced by the flux used and by the quantity of manganese in the charge. Both limestone and fluor spar are useful for removing sulphur with the slag, the latter being the better flux for this purpose. Manganese, too, is a strong desulphuriser, combining with sulphur to form manganese sulphide which is carried in the slag. Under good conditions and using medium-sized scrap, the sulphur contents may be increased by 0.01 to 0.02 per cent., but using light scrap more may be expected in the final composition. The amount of phosphorus varies very little, but since the amount present in the slag is negligible, the amount present in the final metal is similar to that charged, and as the metal that is produced amounts to about 90 per cent. of the metal charged, an increase in the percentage of phosphorus of about 0.02 may be expected. When the temperature of the cupola is high enough to reduce the manganese and make it effective in combining with sulphur, the contents in the metal produced is less than that charged. Under other conditions a loss in manganese is also to be expected because it is oxidised, when the heat of combustion is not high enough to reduce it, and it combines with the flux, being removed in the slag. Thus there is a loss of manganese, the amount varying of course; but in making up mixtures and working under ordinary conditions, usually 10 per cent. of the amount charged is the allowance made for this loss. With fuels or irons high in sulphur a greater loss may be effected when the temperature of combustion is high enough to make it effective.

In working up a charge it is necessary to define the relative contents of each kind of metal charged, and to do this satisfactorily the charge should be worked on a percentage basis. Thus to obtain a mixture for general medium-sized work, No. 3 pig-iron may be used together with scrap. Supposing the charge is 30 per cent. of No. 3 Scotch pig and 70 per cent. good medium-sized scrap, then by reference to the analysis of this pig iron the relative amounts of carbon, silicon, sulphur, phosphorus, and manganese can be calculated. A 100 per cent. of Scotch pig-iron would mean a content of 3.28 per cent. of graphitic carbon, but if the charge is made up of 30 per cent. Scotch pig, then the relative amount of graphitic carbon would be proportional to this amount. Thus 30 by 3.28 divided by 100 will give the amount. Hence for a charge of 30 per cent. of Scotch pig and 70 per cent. of medium-sized scrap the analysis of the metal produced would approximate to the following:—

	G.C.	C.C.	Si.	S.	P.	Mn.
30 per cent. Scotch.						
70 per cent. Scrap ..	0.984 2.17	0.06 0.315	0.645 1.505	0.016 0.056	0.272 0.63	0.39 0.35
Composition of Whole Charge ..	3.154	0.375	2.15	0.072	0.902	0.74
Melting Changes Allowances	—	—	—0.20	+0.02	+0.02	—0.07
Approximate Casting Composition ..	3.154	0.375	1.95	0.094	0.922	0.67

The "VULCANIA" PATENT WHEEL MOULDING MACHINE.

Patent No. 5049.



THE "VULCANIA" PATENT WHEEL MOULDING MACHINE is for moulding spur wheels with straight, sloping or Vee-shaped teeth, also bevel wheels, skew gear wheels, worm wheels and internal wheels. The machine head is carried on a pillar which is held in a base-plate bedded in the floor sand, and is made to slide on the pillar by means of a lever and link carried on a joint bearing, or by rack and pinion, or screw if thought advisable for the particular work it is being used for.

An adjustable stop collar is provided for accurately deciding the depth of mould. On the removable head a slide is carried for supporting the patterns of the teeth to be moulded. This slide is made adjustable by screw or pinion gearing to the diameter required. The number of teeth to be moulded is decided by a special dividing plate into which a steel wedge or finger engages. The special dividing plate has milled vees, at the angle of 60° inclusive, around its circumference, to receive the steel wedge, which is adjusted by a screw having an internal spring to keep it in tension and to lock the head when ramming operations are being carried out.

JAMES EVANS & CO., BRITANNIA WORKS (MANCHESTER), LIMITED.

BLACKFRIARS, MANCHESTER.

This mixture can be modified by including varying percentages of pig-iron or scrap high in the particular element it is desired to increase. Failing a knowledge of the chemical composition of the pig-iron and scrap used, dependence must be placed on the numbers and brands of pig-iron used, together with the approximate information obtained from the fracture of scrap and the purpose for which it has been used. For thin work, up to about ½ in. thickness that is not required to have much strength, the lower-numbered pig-iron should be used, either No. 1 or No. 2. These are soft and capable of taking up a considerable amount of scrap. For such work the metal requires to be very fluid, and therefore the mixture should have sufficient phosphorus to ensure this quality. For medium-sized castings, having metal thickness up to about 1¼ in. and to be of average machining quality, pig-iron of lower silicon contents such as the No. 3 grade is more suitable, and this with scrap that has been used for a somewhat similar purpose will suffice for the charge. For large castings necessitating more strength and toughness the higher numbered grey iron pig should be used, particularly those that are low in phosphorus, such as hematite, together with scrap of known quality. For cylinder work or other castings requiring strength and good wearing qualities and possessing a fine close texture, special cylinder pig may be used, such as Staffordshire cylinder pig, together with a high-numbered hematite or cold-blast pig, and scrap that has been used for similar work. Invariably steel is also introduced in these mixtures in order to close the texture. The scrap used should of course be specially selected for a special mixture of this kind.

In some foundries that frequently require these special mixtures a pig iron is manufactured from various brands and scrap, which is stocked and remelted as required. By this method a more reliable composition is likely to be obtained.

IRON AND STEEL MARKETS.

Pig-iron.

MIDDLESBROUGH.—Business in the Cleveland iron market continues only moderately active, with quotations still inclined to a lower tendency. It is, however, noteworthy that Tees-side ironmasters have now adopted an enterprising policy in bidding for business, No. 3 G.M.B. having been offered in last week's market down to 97s. 6d. per ton, with a view to attracting consumers to extend purchases beyond the hand-to-mouth dealings which have for some time prevailed in the transactions reported. With No. 3 at 97s. 6d., No. 1 is now quoted about 102s. 6d., No. 4 foundry at 92s. 6d., and No. 4 forge at 90s. per ton.

The slight improvement in the demand for hematite recorded last week has been maintained. In the home trade there has been a little more buying in the Sheffield district, and a few more export orders have been booked. But the volume of business passing is still disappointing, even allowing for the restricted output, and there is talk of still further restriction. However, the position on the whole is firmer, and mixed numbers cannot be done at less than 98s. 6d. per ton, with No. 1 at a premium varying from 6d. to 1s. per ton. In West Cumberland and North Lancashire hematite conditions are about the same as last reported, Bessemer mixed numbers being quoted still at £5 10s. per ton delivered at Glasgow and Sheffield, and £5 13s. at Birmingham and South Wales ports. The demand for low phosphorus iron is weaker than that for ordinary iron.

MANCHESTER.—A rather better outlook is reported here in the pig-iron market, orders for delivery over September and October now becoming more frequent at a price based on 92s. 6d. at the Midland furnaces. The condition of the foundry trade in Lancashire is, however, still unsatisfactory, and the total consumption of iron is very far below an average. At present there does not appear to be any undue pressure to sell, and the furnaces are quite firm at 92s. 6d., with one or two holding out for 95s. Scotch pig-iron prices are still quoted at 101s. per ton at the furnaces, but in this market there have been sellers of Scotch iron at rather less than this would mean for delivery in Manchester.

THE MIDLANDS.—Consumers in this area are still buying only in limited quantities, while the demand for foundry iron is below the average, although a somewhat better inquiry is reported from firms producing builders' castings. Altogether business is very inadequate both in volume and price, and it is quite possible that unless there is a speedy change for the better additional furnaces may be damped down. Those smelters whose furnaces are still blowing complain of the impossibility of producing iron at the prices now obtainable, and state that they cannot afford to continue to do so much longer, much as they dislike putting plants out of action. Quotations:—Northamptonshire No. 3 foundry, 90s. to 92s. 6d.; Derbyshire No. 3 foundry, 92s. 6d., all net, f.o.t., furnaces.

SCOTLAND.—The termination of the pattern-makers' strike at Falkirk, just announced, will undoubtedly give a welcome impetus to the demand for pig-iron, which at present remains only moderate in volume. In the Glasgow market some concessions in prices are still being made for reasonably sized orders, indications pointing to a slow but gradual improvement in the position. For any reasonable orders lower prices are being accepted. Quotations nominally are No. 1 G.M.B., 106s.; No. 3, 101s.; hematite, 105s., delivered locally. At a recent meeting of the Pig-iron Trade Association sellers offered No. 3 G.M.B. Scottish at 104s. 6d. f.a.s. Glasgow.

Finished Iron.

No improvement can be reported in the general state of business in finished material, very few of the mills running with any regularity without, unfortunately, much prospect of an early increase in demand. Unquestionably the continued idleness in the ship-building industry is having a prejudicial effect upon the iron trade in all sections, and with the exception of makers of marked bars, manufacturers are in a very difficult position. Crown bar makers, especially, are having a very lean time, and it is difficult to understand how they are able to keep going at all in view of the prices obtainable. One of the reasons, of course, is that they cannot compete with steel in some classes of goods. Their manufacturing costs, owing to the price of fuel and pig-iron, and the rate of wages, are too heavy to permit them to do so, and apparently there is no way of making an adequate cut in costs.

Steel.

Although without any tangible signs of improvement, the steel market discloses a feeling of quiet confidence that the corner has been turned, and that an early improvement in trade in general may be anticipated in the near, if not the immediate, future. Support for this view is probably based on recently issued Admiralty programmes, and a certain amount of activity in electrical circles, particularly in relation to railway and transport developments, which have been responsible for some movement, while it is hoped that railway plans for renewals and extensions will be soon speeded up and contracts placed for the carrying out of such work. Beyond the weakness in billets there is no movement to record in semis.

Scrap.

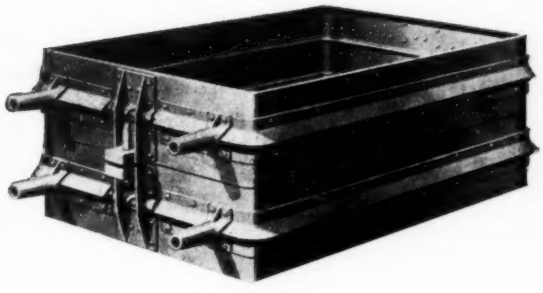
Trade in all sections of scrap material continues quiet, with only a limited demand for particular qualities consumed in foundry production. Supplies of cast scrap are at present in excess of consumption, and there is keen competition among dealers for the orders coming into the market. In Lancashire, the stronger dealers still quote 85s. for textile machinery scrap, and from 80s. to 82s. 6d. for ordinary lots of broken machinery metal; but there are weaker holders who shade even these low prices in their anxiety to make sales.

Metals.

Copper.—The market for standard copper during the past week has been consistently firm, with values usually moving to higher levels, although the volume of business passing has been to some extent disappointing. The marked improvement in the Continental political outlook at this week's opening market should have a strengthening effect generally, while the wholesale destruction of metals in Japan must inevitably influence the statistical position.

The U.K. supply of copper now stands at 27,674 tons as against 26,776 tons in the previous month. There has thus been an increase of 898 tons on the month, but the market is very strong. Current quotations:—*Cash*: Thursday, £64 5s.; Friday, £64 2s. 6d.; Monday, £63 17s. 6d.; Tuesday, £63 15s.; Wednesday, £63 5s. *Three Months*: Thursday £65; Friday, £64 17s. 6d.; Monday, £64 10s.; Tuesday, £64 7s. 6d.; Wednesday, £64.

Sterling



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The Steam that Heats the Air Drives the Fan.

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STEAM TURBINE HEATER UNIT

The Propeller Fan is operated by a small Steam Turbine the exhaust from which passes into a battery of Cast Iron Radiators and is used to heat the air.

IMPORTANT FEATURES OF THE STEAM TURBINE UNIT ARE:—

(a) Lower running costs than with other types of heater units through the Fan driving power being provided free.

(b) No electric cables required, only steam and drain connections being necessary.

(c) No reducing valve required, the turbine acting in that capacity.

(d) No Steam Trap required, complete condensation being obtained.

(e) Absence of mechanical trouble.

WRITE FOR CATALOGUE No. 3.

DAVIDSON & CO., LTD.

Sirocco Engineering Works, BELFAST.

METAL MARKETS—*continued.*

Tin.—Business in the tin market has also developed a more active tendency, the steady upward trend in values culminating in the high figure of £200 and upwards being reached towards the end of the week. American buying was the chief strengthening factor, this resulting in considerable orders being placed on this side and in the East against requirements over the next two months.

Richard & Freiwald's statistics of tin for August are appended :—

STOCKS, LANDING AND AFLOAT, EUROPE AND AMERICA :—United Kingdom : Stocks in London, 1,873 tons ; stocks in other ports, 1,886 tons ; total, 3.759 tons ; landing and in transit, 127 tons ; afloat from Straits, 690 tons ; afloat from Australia, 50 tons ; total United Kingdom, 4,626 tons. Holland : Banca spot, 2,108 tons ; Banca and/or Billiton afloat to Europe and America, 444 tons. Continent : Straits afloat, 595 tons. United States : Spot and landing, 2,887 tons ; afloat, 5,635 tons ; total visible supply, 16,295 tons.

Current quotations :—*Cash* : Thursday, £200 5s. ; Friday, £201 ; Monday, £199 ; Tuesday, £198 10s. ; Wednesday, £199 5s. *Three Months* : Thursday, £201 10s. ; Friday, £202 5s. ; Monday, £200 5s. ; Tuesday, £199 12s. 6d. ; Wednesday, £200.

Spelter.—Demand from galvanisers continues on a fairly active scale, with values well maintained at recent high levels. American advices state that the market there is firm, but production is getting ahead of consumption. At the present level of values it is possible that America will endeavour to get rid of some of her surplus metal over here. Current quotations :—*Ordinary* : Thursday, £33 17s. 6d. ; Friday, £34 ; Monday, £33 12s. 6d. ; Tuesday, £33 12s. 6d. ; Wednesday, £33 15s.

Lead.—Values of soft foreign pig are again on the up grade, a somewhat surprising development in view of the recent heavy arrivals of the metal. Lead stocks now stand at 1,719 tons against 1,815 tons at the beginning of August. It will thus be seen that the country is working on a very slender margin and any revival in world trade would soon have effect on values. Current quotations : *Soft foreign (prompt)* : Thursday, £25 18s. 9d. ; Friday, £25 17s. 6d. ; Monday, £25 12s. 6d. ; Tuesday, £25 5s. ; Wednesday, £25 15s.

Trade Talk.

JAMES BRADSHAW & SONS, Turk Street Engineering Works, Bolton, are giving up business.

ARMSTRONG & MAIN, LIMITED, will in future trade as A. & J. Main & Company, Limited.

FULLER'S UNITED ELECTRIC WORKS, LIMITED, of Chadwell Heath, Essex, have opened a London depôt at 58, High Street, W.C.2.

A LICENCE under the Non-Ferrous Metal Industry Act 1918, has been granted to Mr. F. J. Farrell, Midland Chambers, 17, Westgate Road, Newcastle-on-Tyne.

THE YORKSHIRE PATENT STEAM WAGON COMPANY, of Pepper Road, Hunslet, Leeds, have removed their London office to Abbey House, 8, Victoria Street, London, S.W.1.

MR. E. WHITBY, of 33, Newhall Street, Birmingham, has been appointed sole agent in Birmingham and district for Switchgear & Cowans, Limited, manufacturing electrical engineers, of Old Trafford, Manchester.

NEGOTIATIONS ARE REPORTED to be taking place between the Internal Combustion Engineering Corporation, of New York, and Vickers, Limited, with a view to the formation of a new corporation in which the two companies would be jointly interested.

LAST MONDAY, at Olympia, a luncheon was offered to the Delegation of the American Foundrymen's Association and the council of the London Branch of the Institute of British Foundrymen by the exhibition authorities. Dr. Hele-Shaw presided. Mr. Clamer, on behalf of the Americans, and Mr. V. C. Faulkner, on behalf of the British, thanked Mr. Bridges, the organiser of the exhibition, in brief speeches.

Institute Notes.

Mr. Wesley Lambert finds himself able to take part in the Paris Congress, and crossed with the party last Tuesday. Mr. E. H. Broughall, Vice-President of the Institute, was unfortunately unable to participate owing to a serious accident to one of his workmen.

Messrs. Barbedienne, art founders, of Paris, have also thrown open their works for inspection by the British and American visitors.

The British Cast-Iron Research Association.

Monthly Circular—No. 20.

During the past month further new Members have been elected, including several large firms who recognise the value of the work of the Association.

To fill a vacancy that has occurred on the Council, Mr. F. Fielding, of Messrs. Fielding & Platt, Limited, Gloucester, has been elected to represent the counties of Gloucester, Hereford, and Monmouth. At the next Annual Meeting nine Members of the Council retire, eight of whom are offering themselves for re-election.

Propaganda Work.

The Council will be glad if ironfounding employers associations, or any other section of the industry, would arrange meetings for the Secretary to attend. Several meetings have already been held in various districts which have enabled the officers to discuss with the employers the needs of the industry and the necessity of such an Association.

The Malleable Casting Industry.

Unlike the malleable industry in this country, everything is being done in America to increase the production of malleable castings and to obtain their adoption for every possible engineering use. Their malleable ironfounders firmly believe in research and have practically all joined their research association and have standardised their products.

That malleable ironfounders in this country can produce castings equal to America is proved by some tests taken of castings made by a firm, who are Members of this Association, when the tensile strength recorded was 25.3 tons per sq. in. associated with an elongation of 14 per cent.

The Association consider these figures should be universal in the industry, if the malleable cast-iron founders will join the Association and co-operate with it to obtain a general improvement in the castings, the Association will be able to place before the railway and automobile engineers such reliable data, as will convince them as to the advisability of using malleable castings.

Correspondence.

[*We accept no responsibility for the statements made or the opinions expressed by our correspondents.*]

The West Yorkshire Metallurgical Society.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—I notice in your issue dated September 6 at the commencement of an article entitled "The Farington Steel Works" you mention the "Halifax Metallurgical Society." I do not think such an association exists, but I suggest you intend to refer to a visit to the Farington Works recently made by the West Yorkshire Metallurgical Society at which your representative was present.—Yours, etc.,

H. C. DEWS, Hon. Secretary.

166, Long Lane, Dalton, Huddersfield.
September 10, 1923.

An Interesting Competition.

In our last issue we stated that Beecroft & Partners, Limited, foundry chemists, of Sheffield, were offering a prize for the best slogan or catch phrase for an oil sand core oil which they have recently developed. We very much regret that in consequence of a misunderstanding the prize was announced as 3 guineas instead of £5. Fortunately, attention was drawn to the Company's advertisement on another page, in which the correct sum was stated.

MR. D. COOPER, formerly general manager of the Glasgow and South Western Railway, has been elected a director of the Dalmellington Iron Company, Limited.